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BERGER ASSOCIATES INC HARRISBURG PA
NATIONAL DAM SAFETY PROGRAM. LAKE MEADE DAM, SUSQUEHANNA RIVER --ETC(U)
SEP 78

F/G 13/2

DACW31-78-C-0044

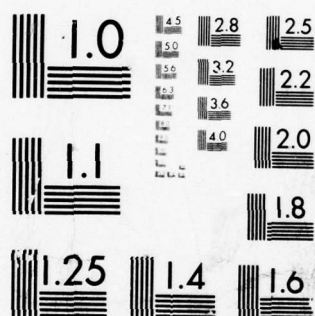
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MICROCOPY RESOLUTION TEST CHART
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⑥ National Dam Safety Program,
Lake Meade Dam, Susquehanna River Basin,
Commonwealth of Pennsylvania, Adams
County (NDS-PA-331). Phase I
Inspection Report.

LEVEL II

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SUSQUEHANNA RIVER BASIN

LAKE MEADE DAM

COMMONWEALTH OF PENNSYLVANIA

ADAMS COUNTY

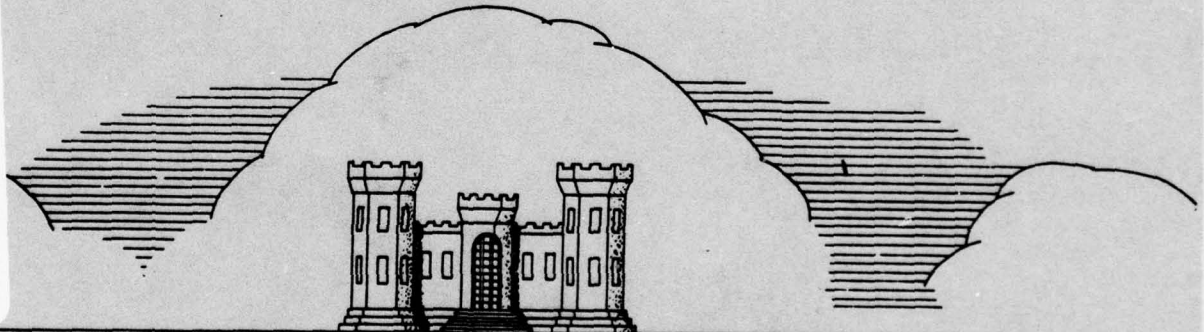
INVENTORY NUMBER NDS PA-331

PHASE I INSPECTION REPORT

NATIONAL DAM SAFETY PROGRAM

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①5 DACW31-78-C-0044



Prepared For
DEPARTMENT OF THE ARMY
Baltimore District, Corps of Engineers
Baltimore, Maryland

by
BERGER ASSOCIATES, INC.
CONSULTING ENGINEERS
HARRISBURG, PA.

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PHASE I REPORT
NATIONAL DAM INSPECTION PROGRAM

Name of Dam: LAKE MEADE
State and State No. PENNSYLVANIA - 1-81-A
County Located: ADAMS
Stream: MUD RUN, SUSQUEHANNA
Date of Inspection: July 21, 1978

ACCESSION for	
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Per Form 50	
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Based on a visual inspection, past performance and available engineering data, the dam and its appurtenances appear to be in good condition. The following recommendations are presented for action by the owner:

1. Trees and brush on the embankment slopes and in the spillway chute shall be removed and the slopes shall be maintained at regular intervals.
2. The outfall of the toe drain shall be exposed and the discharge shall be monitored.
3. Large stones shall be placed downstream of the spillway slab to prevent undermining of this slab.
4. Repair upstream slope riprap in area where some sloughage occurred.
5. Provisions shall be made for emergency closure of the upstream end of the conduit.

The Corps of Engineers' guidelines indicate that a project with the size and hazard potential of this dam should be able to pass the 1/2 PMF without overtopping. Calculations presented in Appendix B indicate that this project has sufficient spillway capacity and storage to pass 51 percent of the PMF. The spillway is, therefore, considered to be adequate.

A formal surveillance and downstream warning system shall be developed by the owner to be used during periods of high and prolonged precipitation.

SUBMITTED BY:

BERGER ASSOCIATES, INC.
HARRISBURG, PENNSYLVANIA

DATE: September 22, 1978



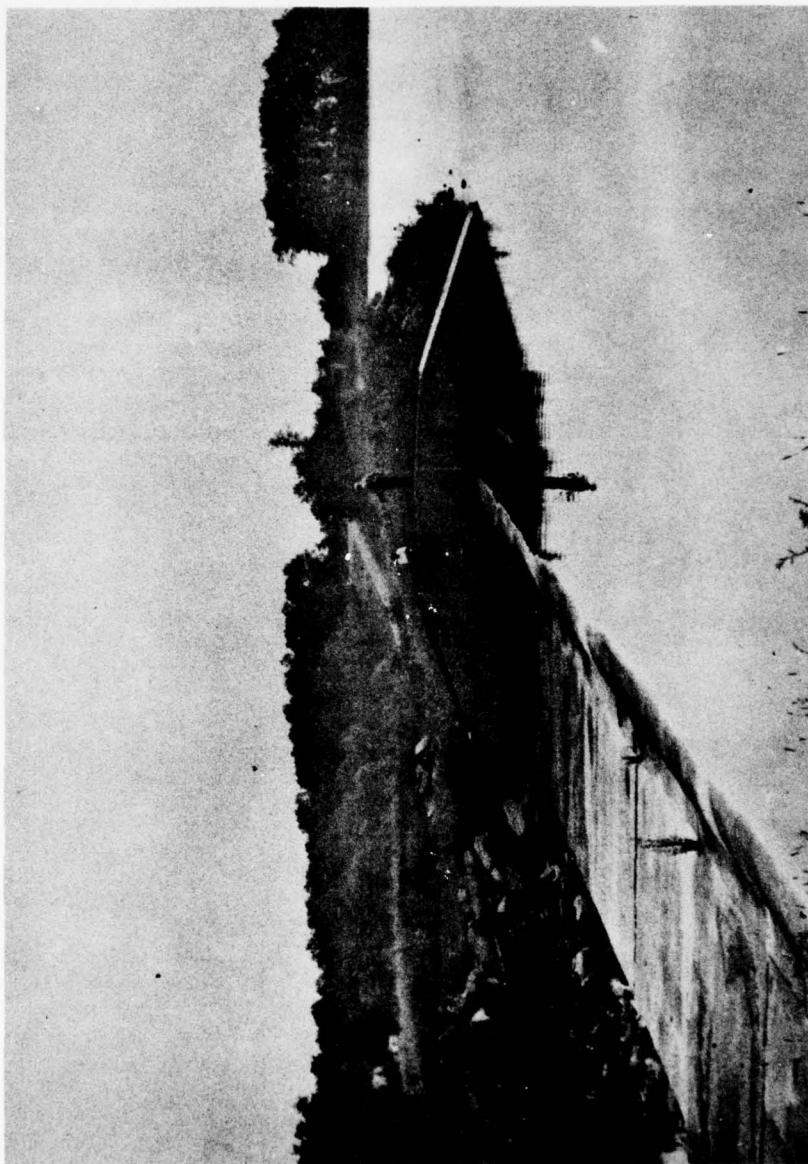
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APPROVED BY:

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G. K. WITHERS
Colonel, Corps of Engineers
District Engineer

DATE: 23 Sep 78



OVERVIEW

SECTION 1 - PROJECT INFORMATION

1.1 GENERAL

A. Authority

The Dam Inspection Act, Public Law 92-367, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a program of inspections of dams throughout the United States. The Phase I Inspection and Report are limited to a review of available data, a visual inspection of the dam site and basic calculations to determine the hydraulic adequacy of the spillway.

B. Purpose

The purpose is to determine if the dam constitutes a hazard to human life and property.

1.2 DESCRIPTION OF PROJECT

A. Description of Dam and Appurtenances

Lake Meade Dam is a rolled earthfill embankment with a maximum height of 42 feet above the streambed elevation. The embankment length is 1,450 feet and a 175-foot-long ogee spillway crest is constructed at the left abutment. The spillway crest elevation is 500, which is 5.0 feet below the top of dam. The spillway channel has a very flat drop and is nearly parallel to the toe of the dam. The chute is excavated in natural rock and joins the natural streambed near the right abutment of the dam. A 24-inch conduit with a valve near the downstream end is the only regulating facility.

- | | |
|----------------------------------|---|
| B. <u>Location:</u> | Latimore & Reading Townships, Adams County
U.S. Quadrangle, Hampton, Pa.
Latitude 40°-00.0', Longitude 77°-02.6'
Appendix D, Plates I and II |
| C. <u>Size Classification:</u> | Intermediate (5330 acre-feet, height
42 feet) |
| D. <u>Hazard Classification:</u> | Significant (See Section 3.1.E) |
| E. <u>Ownership:</u> | Lake Meade Property Owners Association, Inc.
R. D. #1
East Berlin, Pennsylvania 17316 |
| F. <u>Purpose:</u> | Private Recreation
(Real Estate Development) |

G. Design and Construction History

The dam and appurtenant structures were designed by Ralph L. Woolpert Company, Dayton, Ohio. The design was based on a geological and soils report by G. K. Jewel Associates. The original owner was American Realty Service Corporation and a permit for construction was issued on September 6, 1966. There were no records available in the files indicating who the contractor was and presumably most of the construction was performed under supervision of local representatives of the Lake Meade Corporation. Construction was started in September 1966, without supervision of a qualified engineer. After an inspection in 1967 it was discovered that a considerable amount of unsuitable material (cornstalks, wood, grass, etc.) was used in the embankment and that topsoil had not been stripped. This condition was investigated by G. K. Jewell and Associates, who placed an inspector on the job starting June 1967. All unsuitable material was removed, before further construction continued.

The 24-inch outlet pipe was placed on compacted fill rather than on rock. Studies by G. K. Jewel and Associates indicated that the fill and some unsuitable material under the pipe could cause differential settlement of 4-1/2 to 6-1/2 inches over the length of pipe. A pressure test on the pipe indicated some serious leaking through poorly welded joints. The pipe was rewelded and about 765 bags of cement were used for grouting the material under the pipe foundation. The pipe was pressure tested again and the drop in pressure was now within acceptable limits. Placing of additional fill was resumed and substantial completion was reached in December 1967.

H. Normal Operating Procedures

The dam was constructed as a recreational facility for a large suburban development with many of the choice lots located at the water-front created by this dam. The facilities are owned by the association of property owners and the lake is used for recreational purposes. The lake level is maintained at spillway crest elevation during the summer months. In late fall (November) the valve on the 24-inch conduit is opened and a lake level of about 8 feet below spillway crest is maintained during the winter months. The main purpose of this lower level is to prevent ice damage to boat docks.

1.3 PERTINENT DATA

A. Drainage Area (square miles)

Computed for this report
(Original design used 8.5 sq.mi.)

8.8

B. Discharge at Dam Site (cubic feet per second)
See Appendix B for hydraulic calculations.

Maximum known flood, September 26, 1975, estimated
on basis of high water mark at Elev. 502.75 2,800

Warm water outlet None

Outlet works low-pool outlet at pool Elev. 473 30

Outlet works at pool level Elev. 500 (spillway crest) 80

Spillway capacity at pool Elev. 505 (top of dam) 7,400

C. Elevation (feet above mean sea level)

Top of dam (top of dam is rounded from 505 at edges
to 505.5 on centerline) 505

Spillway crest 500

Upstream portal invert of outlet tunnel 470.41

Downstream portal invert of outlet tunnel 467.30

Streambed at centerline of dam 463

Maximum tailwater about 475

D. Reservoir (miles)

Length of maximum pool 1.4

Length of normal pool 1.3

E. Storage (acre-feet)

Spillway crest (Elev. 500) 3,680

Top of dam (Elev. 505) 5,330

F. Reservoir Surface (acres)

Top of dam (Elev. 505) 371

Spillway crest (Elev. 500) 291

G. Dam

See Plates VI through XII, Appendix D, for plan and sections.

Type: Rolled homogeneous earthfill.

Length: 1450 feet of embankment and 175 feet of spillway.

Height: 42 feet above streambed.
49 feet above bottom cutoff trench.

Top Width: 20 feet.

Side Slopes: Upstream 3H to 1V with a 5-foot berm at Elev. 497
Downstream 2.5H to 1V.

Zoning: Homogeneous

Cutoff: Trench excavated a minimum of 3 feet in rock
and a bottom width of 20 feet on the centerline
of the dam and filled with embankment material.

Grout Curtain: None.

H. Outlet Facilities

Water may be released from the reservoir through a 24-inch spiral-welded steel pipe which passes through the embankment. The pipe is 286 feet long and has invert elevations of 470.41 at the upstream end and 467.30 at the downstream end. The upstream end is uncontrolled and is provided with a bar screen. Flow in the pipe is controlled by means of a 24-inch gate valve located in a concrete control box at the downstream toe of the embankment and about 40 feet from the end of the pipe. An uncontrolled one-inch copper pipe bypasses the valve and provides the required release of 100,000 gallons per day.

I. Spillway

Type: Uncontrolled, standard type crest, ogee weir.

Length: 175 feet.

Crest Elevation: 500 feet.

Upstream channel: Approach channel is 33 feet long, 175 feet wide, and 3 feet deep at normal pool stage.

Downstream channel: With the exception of a 15-foot concrete apron, immediately downstream from the weir and a 200-foot section at the end, the entire 1,400 feet of chute is unlined excavation in hard rock. The rock surface is very rough and, in addition, 6-foot high brush has been allowed to flourish on it. The estimated "n" value for the chute flowing full would be about 0.05.

The weir is at the left end of the dam. For the first 190 feet the chute continues in a direction perpendicular to the axis of the dam. It then makes a 90-degree turn to the right and continues in a direction parallel to the axis of the dam until it reaches the original bed of Mud Run. The distance between the centerlines of the dam and the chute is about 190 feet. At Mud Run, the chute terminates with an 80 degree turn to the left. There is a stilling basin measuring 40 feet by 40 feet by 5 feet deep about halfway down the chute.

The last 200 feet of the chute is excavated in earth and is lined with 3-foot diameter stones.

The chute is trapezoidal in shape, having a bottom width of 50 feet and sideslopes of 2.5H to 1V.

The capacity of the chute appears to be adequate for the top-of-dam weir discharge of 7,400 cfs but it is recommended that the conveyance of the chute be maintained by removing the brush.

J. Regulating Outlet

A 24-inch gate valve at the downstream toe of the embankment regulates the flow of water in a 24-inch diameter steel pipe which passes through the embankment.

SECTION 2 - ENGINEERING DATA

2.1 DESIGN

A. Data Available

1. Hydrology and Hydraulics

The hydrologic and hydraulic data available from the files of the Pennsylvania Department of Environmental Resources (PennDER) for this dam was limited.

The report by PennDER upon the application for a permit to construct this dam states that the required spillway capacity should be 7120 cfs for a drainage area of 8.5 square miles. The design was considered satisfactory, although this flow would leave very little freeboard.

2. Embankment

The embankment design as detailed on the construction drawings was based on a soils report by G. K. Jewel Associates, acting as the soils engineer for the designer. This report includes soils test data from consolidated quick test, unit weights (dry and wet), gradation, boring results and a geologic report. Design recommendations for the embankment slopes were based on a slope stability analysis.

3. Appurtenant Structures

Design criteria and design analysis of the appurtenant structures were not available in the files of PennDER or at the owners office. A full set of construction drawings were available at the office of the owners. The drawings in the PennDER files do not reflect all changes made after construction started. Drawings shown in Appendix D reflect the design drawings used for construction.

B. Design Features

1. Embankment

The construction drawings (Appendix D, Plate IX) show that the embankment is a homogeneous earthfill structure with a 3H to 1V upstream slope and a 2.5H to 1V downstream slope. The crest width is 20 feet and a 5-foot-wide berm is on the upstream slope at elevation 497.0.

All topsoil and organic material was to be removed under the embankment and on the centerline of the dam a cutoff trench was to

be excavated. This trench was to extend three feet into rock and have a bottom width of 20 feet and was backfilled with embankment fill.

The upstream slope above the berm is protected with 18 inch dumped riprap on a 12-inch gravel filter. The downstream slope was seeded and a toe drain was installed over the full length of the toe.

2. Appurtenant Structures

The spillway weir is a reinforced concrete weir keyed into rock and gravel filled drains were provided. A concrete approach slab and downstream slab and concrete retaining walls form the actual spillway section. Below this short downstream slab the spillway chute is excavated in rock and is protected by large dumped stone. The 24-inch welded steel pipe conduit is encased in reinforced concrete (Appendix D, Plate X) and has cutoff collars over its full length. The intake is submerged and the valve is located at the downstream toe in a valve chamber.

C. Design Data

1. Hydrology and Hydraulics

PennDER's permit application report states that the required spillway discharge for this structure should be 7120 cfs to meet the "C" curve criteria. The actual capacity of the spillway was calculated to be 7666 cfs, with no allowance for freeboard.

2. Embankment

The embankment design was based on a soils report which reported test results on borrow material, borings and recommended embankment slopes. Slope stability analysis indicates a factor of safety against failure of at least 1.5.

3. Appurtenant Structures

Design criteria or design calculations were not available for review. The available data is limited to design drawings.

2.2 CONSTRUCTION

The available construction data consists of the original construction drawings and construction progress reports. Many reports indicating field test results for compaction and moisture content are also in the files. Construction started in the fall of 1966 without inspection by a qualified engineer. Large quantities of unsuitable material were used

and this was removed next year before further construction was permitted. During 1967 a representative of G. K. Jewel and Associates was on the site and performed the compaction tests.

The 24-inch pipe was placed in 1966 and was located on top of three feet of fill. Many leaks in the pipe were discovered when a pressure test was made. The pipe was rewelded at these locations and the supporting fill was grouted.

The original design drawings indicated a bathtub type spillway at the east (right) abutment. Revisions were made in December 1966, after construction had started, detailing an ogee type weir located in the west abutment.

2.3 OPERATION

No formal records of operation are maintained by the owners. During the summer the lake level is preferred to be at the spillway crest elevation. The valve on the 24-inch conduit is opened in November to maintain a lake level of approximately 8 feet below spillway crest during the winter months.

2.4 EVALUATION

A. Availability

A full set of design drawings were obtained from the owners for review. The files of PennDER contained most of the drawings and include the report by the soils engineer and construction information.

B. Adequacy

1. Hydrology and Hydraulics

The available hydrologic and hydraulic analysis for Lake Meade is not very extensive and was limited to a permit application report which stated that the spillway capacity was sufficient to pass the required "C" curve discharge. Area capacity curve, spillway rating curve, frequency curve, unit hydrograph, design storm, design flood hydrograph or flood routings were not available for review.

2. Embankment

The available construction data including the compaction field tests is considered adequate to assess the embankment design. It is considered that the constructed embankment is in accordance with accepted engineering practice, except that measures for control of through seepage are considered minimal.

3. Appurtenant Structure

Although no actual design criteria or design analysis were available for review, the design drawings indicate that the spillway and spillway retaining walls are adequately designed for normal operating procedures. The walls appear to be stable and well constructed. A question arises concerning the metal pipe for the conduit which was rewelded at certain points. Presumably this was done before the concrete encasing was placed.

C. Operating Records

No formal operating records are maintained by the owner. It was reported that since the facility became operable, no major problems have occurred. Tropical storm Eloise (September 1975) did not cause any damage to the structure.

D. Post Construction Changes

There are no records of changes or modifications after completion of construction.

E. Seismic Stability

The dam is located in Seismic Zone 1 and it is considered that the static stability with normal safety margins is such that the dam will withstand minor earthquake induced dynamic forces. No calculations were made to confirm this.

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS

A. General

The general appearance of the dam was good. A considerable amount of weed growth was present at the time of inspection and close observation of the downstream slope was not feasible. Only one wet area near the valve box was discovered. The alignment and profile of the embankment appeared to be good. Maintenance of the slope is done only as directed by PennDER, after a written notice is received. The top of the embankment had been mowed recently, but the downstream slope is covered with high weeds. Refer to Appendix D, Plate III.

B. Embankment

Heavy boulders with sizes up to 4 to 5 feet were placed at the downstream toe of the embankment over the toe drain. The downstream slope had heavy weed growth and some small trees and it was difficult to detect possible problems. No sloughing or erosion was detected and the only seepage observed was beyond the toe near the valve box. This could come from the toe drain (Appendix D, Plate VII). The outfall of the toe drain could not be located. Weeds are also growing on the upstream slope above the waterline. The upstream slope is covered with large stone, but does not have a well-graded riprap cover to prevent movement of the rock. One area of slope failure was noted. This area should be corrected when the lake is drawdown during the next winter season.

C. Appurtenant Structures

The spillway weir is located near the left abutment. The concrete weir and retaining walls were in good condition. Some minor cracking has occurred in the slabs below the weir. It appears that the slab was poured on rock and if the cracks do not widen, no future problems are expected. At the end of the spillway slab a large part of the downstream cutoff wall is exposed. The placing of large boulders should be recommended to prevent undermining of this slab. Most of the long spillway chute is excavated in rock and unlined. The rock appears to be hard. The chute makes a 90-degree right bend close to the spillway and then parallels the toe of the embankment over a length of 1200 feet. Possible erosion could occur opposite the weir where the channel makes the bend, but this would not affect the safety of the structure.

The drawdown pipe has a submerged intake and is controlled by a valve in a valve box located close to the right abutment. This concrete

valve box projects about five feet above the ground surface and is surrounded by heavy growth. A ladder is required to reach the top of the valve box, where a concrete manhole cover supplies access to the inside. Two or three men are required to lift this cover. The inaccessibility prevents vandalism and in time of emergency, enough manpower would be available to overcome these difficulties.

The valve operation in the box was not inspected. It is our understanding that it takes two men to operate the valve. The valve is operated at least twice a year (Fall and Spring) to lower the reservoir level during the winter.

D. Reservoir Area

The reservoir was created as part of a land development project and is used for recreation (boating). Houses are located around the shoreline and well maintained lawns form the banks of the lake. Not all lots have been developed yet. No signs of serious erosion were noticed.

E. Downstream Channel

The downstream channel is a natural stream channel and passes underneath a bridge about 300 feet below the centerline of the dam. The stream is rather small and has heavy brush and tree growth on its banks. The stream meanders through a mostly agricultural area and joins the Bermudian Creek approximately 7.0 miles downstream from the dam. Only one house is located close to the stream and the hazard category is considered to be "Significant".

3.2 EVALUATION

The general appearance of the facility was good. The heavy weed growth and small trees on the embankment slopes should be removed and the riprap on the upstream slope should be repaired.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURE

Lake Meade was created as a recreational facility for the Lake Meade realty development. The dam is owned by the Lake Meade Property Owner's Association and the pool level is maintained at spillway crest elevation in the summer. To prevent damage to boat docks by ice and to facilitate maintenance work on the boat docks, the pool is drawn down about 8 feet during the winter months by opening the 24-inch valve. The valve is generally closed again in March or early April.

4.2 MAINTENANCE OF DAM

The Association has created a \$25,000 fund as required by PennDER to guarantee annual maintenance. The maintenance of the embankment is kept to a minimum and besides mowing the breast of the dam, other maintenance is only carried out if instructed by PennDER after their annual inspection.

4.3 MAINTENANCE OF OPERATING FACILITIES

The only operating facility is the valve on the 24-inch drawdown line in the valve box. This valve is opened or closed twice a year and no specific maintenance (greasing) is done. The valve is difficult to operate and access requires a ladder and two men to lift the manhole cover.

4.4 WARNING SYSTEM

There is no formal warning system in effect. Owner's representatives are living around the lake and a surveillance plan in times of high precipitation should be developed.

4.5 EVALUATION

It is recommended that a better maintenance program for the embankment be developed. This should include the removal of all brush and tree growth and a regular mowing of the embankment. Although the valve is not very accessible, a better access with padlocks is not necessary for these Association-owned facilities.

SECTION 5 - HYDROLOGY/HYDRAULICS

5.1 EVALUATION OF FEATURES

A. Design Data

The hydrologic and hydraulic analysis available from PennDER for Lake Meade Dam was not very extensive. No area-capacity curve, frequency curve, unit hydrograph, design storm, design flood hydrograph, nor flood routings were submitted by the designer to PennDER.

In order to obtain a permit from PennDER, the owner had to provide enough spillway capacity to meet PennDER's "C" curve criterion which is explained in PennDER Publication No.41, "Construction or Repair of Dam", 1975. For a drainage area of 8.5 square miles used by the designer, the "C" curve calls for a spillway capacity of 7,120 cfs. The project is designed to pass 7,666 cfs with no freeboard.

A complete set of construction drawings was available.

B. Experience Data

In the period that the dam has been in existence, from 1968 to the present, the maximum flood was that of September 26, 1975, when the flow was about 2,800 cfs (Appendix B). The spillway passed that flood without distress.

C. Visual Observations

On the date of the inspection, no conditions were observed that would indicate that the appurtenant structures of the dam could not operate satisfactorily during a flood event, until the dam is overtopped.

The growth of brush in the unlined spillway chute should be removed each year as it makes a considerable reduction in the available capacity.

D. Overtopping Potential

This dam has a size classification of "Intermediate" (42 feet high and 5,330 acre-feet of storage) and a hazard potential classification of "Significant" (Mud Run flows seven miles through flat farmlands to a confluence with Bermudian Creek, which has a larger drainage area. There appears to be only one house in this reach. In the first six miles of Bermudian Creek, below the confluence, there are about 20 low-lying homes).

The Recommended Spillway Design Flood (SDF) for a dam with the above classifications is in the range 1/2 Probable Maximum Flood (PMF) to PMF. The 1/2 PMF value is recommended for this site since the 20 homes are a considerable distance downstream and at a place where the stream has a much larger drainage area.

The 1/2 PMF peak flow for this site is 9,600 cfs (See Appendix B) and the spillway capacity at top of dam level (Elev. 505) is about 7,400 cfs or 38 percent of PMF peak flow. See Appendix B for hydraulic computations.

An estimate of the storage effect of the reservoir shows that Lake Meade has the storage available that is necessary to pass the 1/2 PMF without overtopping (See Appendix B).

E. Spillway Adequacy

The spillway capacity is considered to be adequate as the project will pass 51 percent of the PMF without overtopping the dam.

The hydrologic analysis for this investigation was based upon existing conditions of the watershed. The effects of future development were not considered.

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY

A. Visual Observations

1. Embankment

There are no visual indications of settlement or sloughing of the embankment slopes. The only point of concern was a wet area near the valve box. This wet condition could be caused by the drain system in the toe. A small area of the upstream slope where large stone had moved slightly needs some maintenance.

2. Appurtenant Structures

The visual inspection of the spillway, spillway chute and valve box did indicate that all structures are in good condition. There was no excessive cracking, spalling or deflection in any of the structures. The deep exposure of the downstream cutoff wall of the weir would indicate the need of placing some heavy stone in this area.

B. Design and Construction Data

1. Embankment

Based on test pit results and core borings, G. K. Jewel Associates prepared a design report and recommended the embankment slopes as shown on the drawings. The reported factor of safety for slope stability was more than 1.5 for the upstream and downstream slopes. The report listed the results of gradation, consolidated quick tests, unit weights (dry and wet) and a geological review of the dam foundation. Rock is close to the surface as was apparent in the cut for the spillway chute. Provisions for control of through seepage are minimal and because of the growth on the downstream slope, the inspection for wet spots was limited.

The construction started without competent supervision and a considerable amount of unsuitable material had to be replaced after G. K. Jewel Associates placed a representative at the site for inspection. The files contain many reports of compaction and moisture content tests. If either one did not meet the criteria, the placed material was reworked. A sheepsfoot roller was used for compaction.

Although many difficulties were encountered during construction, the slopes of the embankment appear to be adequate for the

height of the dam. No filter blanket is shown on the design drawings, but a toe drain is detailed. The cutoff trench was carried three feet into solid rock.

2. Appurtenant Structures

The original construction drawings called for a bathtub type spillway. This was changed in December 1966, to an ogee weir in the left abutment as detailed in the drawings in Appendix D. The spillway weir and abutment walls are all set on rock, but no rock anchors have been used. The weir and footings have been keyed into rock. Details shown on the drawings appear adequate; however, there were no as-built drawings available for review and it is not known how close the actual excavation could match the neat lines shown on the construction drawings. A note specifies that all loose and broken rock had to be removed and replaced by concrete.

The 24-inch drawdown line is a spiral welded pipe encased in concrete. As discussed in Section 1.3.G of this report, the pipe encasing support fill was grouted after some of the fill had been placed. The submerged intake of the pipe consists of a headwall and wingwalls with a steel trash rack. Details of this structure and the pipe appear to be adequate.

C. Operating Records

No formal operating records are maintained for this dam. The owner's representative stated that recent heavy storms (Agnes and Eloise) did not cause any serious problems for the dam and its appurtenant structures.

D. Post Construction Changes

There have been no reported modifications to the original dam design.

E. Seismic Stability

This dam is located in Seismic Zone 1 and it is considered that the static stability is sufficient to withstand minor earthquake induced dynamic forces. No studies or calculations have been made to confirm this assumption.

SECTION 7 - ASSESSMENT AND RECOMMENDATIONS

7.1 DAM ASSESSMENT

A. Safety

The visual inspection, the review of available design data and the operational history indicate that Lake Meade Dam is in good condition and has been designed in accordance with acceptable engineering practice. The use of unsuitable material in the early stages of construction was rectified after a qualified inspector was placed in charge.

Although the structure was designed with very little freeboard, hydraulic calculations indicate that the combination of storage capacity and spillway discharge is sufficient to pass 51 percent of the PMF and, therefore, the spillway is considered to be adequate in accordance with the Corps of Engineers' guidelines.

B. Adequacy of Information

The available information is considered to be sufficient to make a reasonable assessment of this project.

C. Urgency

It is considered that the recommendations suggested in this section should be implemented as soon as practical.

D. Necessity for Additional Studies

Additional studies by the owner are not required at this time. However, attention should be given to the recommendations presented in this section.

7.2 RECOMMENDATIONS

A. Facilities

In order to assure the continued satisfactory operation of this dam, the following actions are recommended:

1. The outfall of the toe drain should be exposed and the discharge should be monitored.
2. The owner should place large stones at the downstream end of the spillway slab to prevent additional scour.

3. The owner should repair the riprap on the upstream slope where a slight failure has occurred. The drawdown during the winter months would facilitate this repair.
4. Provision should be made for the temporary blocking of the conduit at the upstream end for closure in the event of an emergency.

B. Operation and Maintenance Procedures

1. The owner should establish a maintenance procedure to remove trees and brush from the embankment slopes and spillway channel at regular intervals.
2. It is considered important that a formal surveillance and downstream warning system be developed by the owner to be used during periods of high and prolonged precipitation.

APPENDIX A
VISUAL INSPECTION

CHECK LIST - DAM INSPECTION PROGRAM

PHASE I - VISUAL INSPECTION REPORT

NAD NO. 331

PA. ID # 1-81-A NAME OF DAM Lake Meade HAZARD CATEGORY Significant

TYPE OF DAM: Earthfill

LOCATION: Latimore and
Reading TOWNSHIP Adams COUNTY, PENNSYLVANIA

INSPECTION DATE 7/21/78 WEATHER Sunny - Hot TEMPERATURE 80° - 90°

INSPECTORS: H. Jongsma, R. Houseal D.E.R.
R. Steacy, A. Bartlett Walter Leidig
Paul Cardosik

NORMAL POOL ELEVATION: 500 AT TIME OF INSPECTION:

BREAST ELEVATION: 505.0 POOL ELEVATION: 500

SPILLWAY ELEVATION: 500 TAILWATER ELEVATION: None

MAXIMUM RECORDED POOL ELEVATION: 1975 502.8±

GENERAL COMMENTS:

Lake is drained every year to permit repair to boat docks around the lake. Down 8 feet.

Valve last opened November, 1977 and closed March, 1978.

The growth on the dam should be controlled.

Downstream Slope: Surface soil appears sandy - subject to erosion.

No surveillance.

Maintenance of slope is done on as directed by D.E.R. Mowes top only.

VISUAL INSPECTION

EMBANKMENT	OBSERVATIONS	REMARKS & RECOMMENDATIONS
A. SURFACE CRACKS	None observed.	
B. UNUSUAL MOVEMENT BEYOND TOE	Area beyond toe has been filled or is natural ground of higher elevation.	
C. SLOUGHING OR EROSION OF EMBANKMENT OR ABUTMENT SLOPES	None evident - heavy weed growth makes it difficult to see any problems.	
D. VERTICAL & HORIZONTAL ALIGNMENT OF CREST	Horizontal - o.k. Vertical - o.k. difficult to check with tall grass.	
E. RIPRAP FAILURES	None evident - the cover is a wide range of boulder sizes - could not detect any distress. One small failure on upstream slope.	
F. JUNCTION EMBANKMENT & ABUTMENT OR SPILLWAY	Abutments sound	
G. SEEPAGE	Wet area left of valve box. Flow visible through the rock toe up to 50' left. Seepage not detected on slope or at other locations along toe.	
H. DRAINS	None visible, 8" pipe in toe drain.	
J. GAGES & RECORDER	None	
K. COVER (GROWTH)	Downstream: Heavy growth of brush and some small trees. Rock up to 5 feet on toe of slope. Top: Weeds and stoned wheel tracks Upstream: Weeds between dumped rock. Irregular due to large stone.	

VISUAL INSPECTION

OUTLET WORKS	OBSERVATIONS	REMARKS & RECOMMENDATIONS
A. INTAKE STRUCTURE	No tower. Submerged inlet - not visible.	
B. OUTLET STRUCTURE	Concrete valve box with concrete cover for access. Difficult access. Very heavy manhole cover.	
C. OUTLET CHANNEL	Narrow shallow channel with many boulders and heavy brush (this is the spillway channel also).	
D. GATES	24" gate valve in the outlet structure.	
E. EMERGENCY GATE	See D.	
F. OPERATION & CONTROL	None	
G. BRIDGE (ACCESS)	None	

VISUAL INSPECTION

SPILLWAY	OBSERVATIONS	REMARKS & RECOMMENDATIONS
A. APPROACH CHANNEL	Stone lined walls on left side - embankment on right.	
B. WEIR: Crest Condition Cracks Deterioration Foundation Abutments	Concrete - Ogee section in excellent condition. Water not flowing over the spillway. Walls - concrete in excellent condition.	
C. DISCHARGE CHANNEL Lining Cracks Stilling Basin	Rock bottom beyond spillway runout slab. Dumped rock for first 150'± on slopes downstream. Channel is filled with weed growth.	
D. BRIDGE & PIERS	None	
E. GATES & OPERATION EQUIPMENT	None	
F. CONTROL & HISTORY	Maximum flow over weir during Eloise (2.75 feet) No problems.	

VISUAL INSPECTION

MISCELLANEOUS	OBSERVATIONS	REMARKS & RECOMMENDATIONS
<u>INSTRUMENTATION</u>		
Monumentation	None	
Observation Wells	None	
Weirs	None	
Piezometers	None	
Other	None	
<u>RESERVOIR</u>		
Slopes	The area is residential with homes and lawns adjacent to the lake.	
Sedimentation	None known.	
<u>DOWNSTREAM CHANNEL</u>		
Condition	Small stream - heavy growth on overbanks Stone bottom	
Slopes	Heavy brush and trees.	
Approximate Population	4	
No. Homes	One	

APPENDIX B
HYDROLOGY/HYDRAULICS

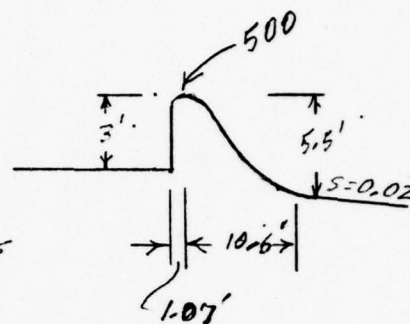
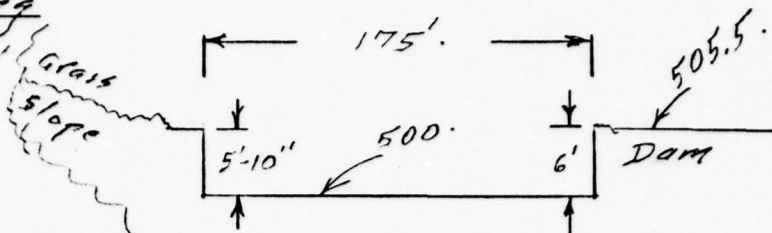
Spillway Rating

Top of dam is rounded
 505 at edges
 505.5 on E
 Use Elev. 505
 for top of dam

$$Q = CL(H)^{3/2}$$

$$= 3.8 \times 175 \times (5)^{3/2}$$

$$= 7430 \text{ cfs}$$



Max Known Flood

Storekeeper said 1975 flood was higher than 1972 flood. She pointed out highwater mark for 1975 flood. Levels showed mark was 33 inches above spillway crest or Elev. 502.75.

Ref. King Fig. 5-27

$$H/H_0 = \frac{2.75}{5.00} = 0.55$$

$$C/C_0 = 0.93 \quad 0.93 \times 3.8 = 3.53 = C$$

$$Q = CL(H)^{3/2} = 3.53 \times 175 \times (2.75)^{3/2}$$

$$= 2800 \text{ cfs}$$

USGS gaging station downstream from this site is West Connelago Creek near Manchester, Drainage area 510 sq. mi. Highest flood 1928 to present - 96,200 cfs Sept. 26, 1975.

Transposing to Lake Meade Dam

$$\left(\frac{8.8}{510}\right)^{0.8} \times 96,200 = 3,740 \text{ cfs}$$

Since the indicated ^{discharge} would be reduced by storage, 2,800 cfs seems reasonable

For maximum known flood, use

2,800 cfs Sept. 26, 1975.

Outlet works - low pool.

The outlet works consists of 286 feet of 24-inch diameter spiral welded steel pipe with a 24 inch gate valve 140 feet from the downstream end. Invert elevations are 470.41 at upstream end and 467.30 at downstream end. Use Elev. 473 for low pool.

Consider entrance as an orifice

$$Q = C a \sqrt{2gh}$$

$$= 0.6 \times 3.14 \times (64.3 \times 4.7)^{1/2}$$

$$= 33 \text{ cfs}$$

Use 30 cfs

$$C = 0.6$$

$$a = \pi R^2$$

$$= 3.14$$

$$h = 473 - 468.3$$

$$= 4.7$$

Outlet works at pool Elev. 500

$$Q = C a \sqrt{2gh}$$

$$= 0.6 \times 3.14 \times (64.3 \times 31.7)^{1/2}$$

$$= 85 \text{ cfs}$$

Use 80 cfs

$$C = 0.6$$

$$a = 3.14$$

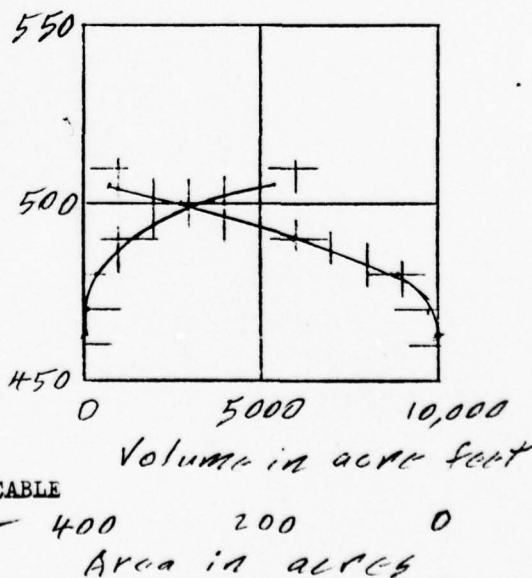
$$h = 500 - 468.3$$

$$= 31.7$$

Area - Capacity

Elev. (ft)	Area (acres)	Vol. (ac ft)	Tot. Vol. (ac ft)
463	0	42	0
470	12	305	42
480	49	1060	347
490	163	2270	1407
500	291	1655	3677
505	371		5332

Elev. in feet.



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Probable Maximum Flood

Drainage Area 8.8 square miles
 C. of E. says to use Indian Rock Resv. PMF

$$\begin{aligned} &0.8 \quad 93.7 \text{ sq mi} \quad 128,000 \text{ cfs} \\ &\left(\frac{8.8}{93.7}\right) \times 128,000 = 19,300 \text{ cfs} \quad \left\{ \begin{array}{l} \frac{1}{2} \text{ PMF} = 9,600 \text{ cfs} \end{array} \right. \end{aligned}$$

Spillway Adequacy ($\frac{1}{2}$ PMF)

$$\frac{\text{Maximum Spillway Discharge}}{\text{Peak Inflow}} = \frac{7,400}{19,300}$$

$$\begin{aligned} &= 0.384 \text{ PMF} \\ &= .77 \text{ of } \frac{1}{2} \text{ PMF} \end{aligned}$$

$$\frac{\text{Req. Resv. Storage}}{\text{Vol. of Inflow}} = 0.23$$

From short cut routing method
 furnished by Balt. Dist. C. of E.

$$\begin{aligned} \text{Vol. of Inflow for } \frac{1}{2} \text{ PMF} &= 13 \text{ inches runoff} \\ &= 53.33 \times 13 \times 8.8 \\ &= 6,100 \text{ acre feet} \end{aligned}$$

$$\begin{aligned} \text{Req. Resv. Storage} &= 0.23 \times 6,100 \\ &= 1,403 \text{ acre feet} \end{aligned}$$

$$\begin{aligned} \text{Available Storage} &= 4332 - 3677 \\ &= 1655 \text{ acre feet} \end{aligned}$$

Lake Meade does have the storage
 required to pass $\frac{1}{2}$ PMF

Spillway Adequacy (Cont.)

7/10 PMF $0.7 \times \text{PMF} = 0.7 \times 19,300$
 $= 13,500 \text{ cfs}$

$\text{PMF runoff (26")} = 53.33 \times 26 \times 8.8$
 $= 12,200 \text{ acre feet.}$

$0.7 \text{ PMF runoff} = 0.7 \times 12,200$
 $= 8,540 \text{ acre feet.}$

$\frac{\text{Max Spillway Q}}{0.7 \text{ PMF peak inflow}} = \frac{7,400}{13,500} = 0.55$

$\frac{\text{Req. Resv. Stor.}}{\text{Vol. of inflow}} = 0.45$

$\text{Req. Resv. Stor.} = 0.45 \times 8,540 = 3,840 \text{ ac. ft.}$

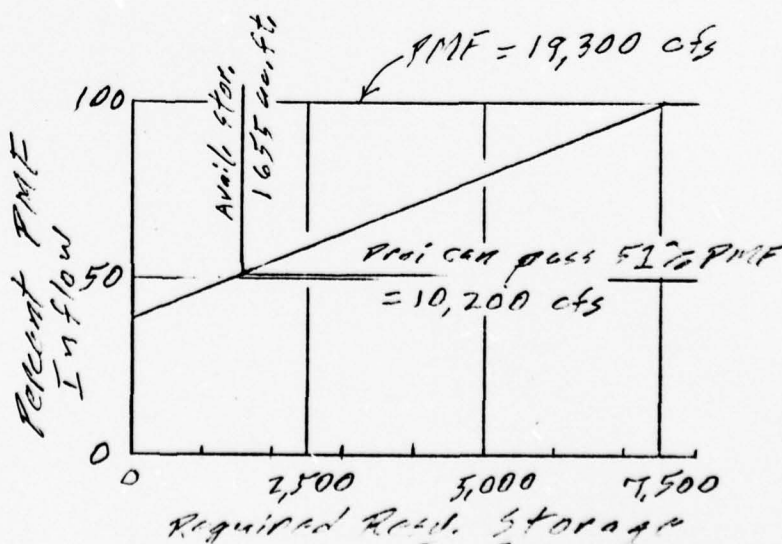
PMF $\text{PMF} = 19,300 \text{ cfs}$
 $\text{PMF Vol.} = 12,200 \text{ acre feet.}$

$\frac{\text{Max Spillway Q}}{\text{PMF peak Inflow}} = \frac{7,400}{19,300} = 0.38$

$\frac{\text{Req. Resv. Stor.}}{\text{Vol of Inflow}} = 0.62$

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$\text{Req. Resv. Stor.} = 0.62 \times 12,200 = 7,564 \text{ ac. ft.}$



APPENDIX C
GEOLOGIC REPORT

GEOLOGIC REPORT

Bedrock - Dam and Reservoir

Formation Name: Triassic Diabase.

Lithology: Diabase is an intrusive igneous rock, composed essentially of pyroxene and feldspar. Quartz, ilmenite, and magnetite are common accessory minerals. The fresh rock is gray to dark gray with massive crystalline texture.

Structure

The dam is located near the top of a sheet-like igneous intrusive, which was intruded into the Gettysburg shale. Here it is nearly parallel to the bedding of the shale. The contact of the diabase with the shale just east of the dam is the top of the sheet, which dips gently to the east, beneath the shale.

The diabase is commonly extensively jointed, and near the top, the joints often form hexagonal columns.

Air photo fracture traces trend N10°W, N12°E, N75°E, N78°W and N35°W.

Overburden

Core boring logs describe the overburden as "silty clay" and "medium dense brown sand". This is typical of material derived from weathered diabase. Below the dense brown sand the material is described only as "rock". Apparently, the transition to fresh rock was abrupt here, as it generally is.

The thickness of overburden along the centerline of the dam varied from 0, outcrop, to 12 feet, averaging about 7 feet.

Aquifer Characteristics

Diabase is a very impermeable rock. Ground water movement is entirely along joints and fractures. There is very little ground water movement below the weathered zone.

Discussion

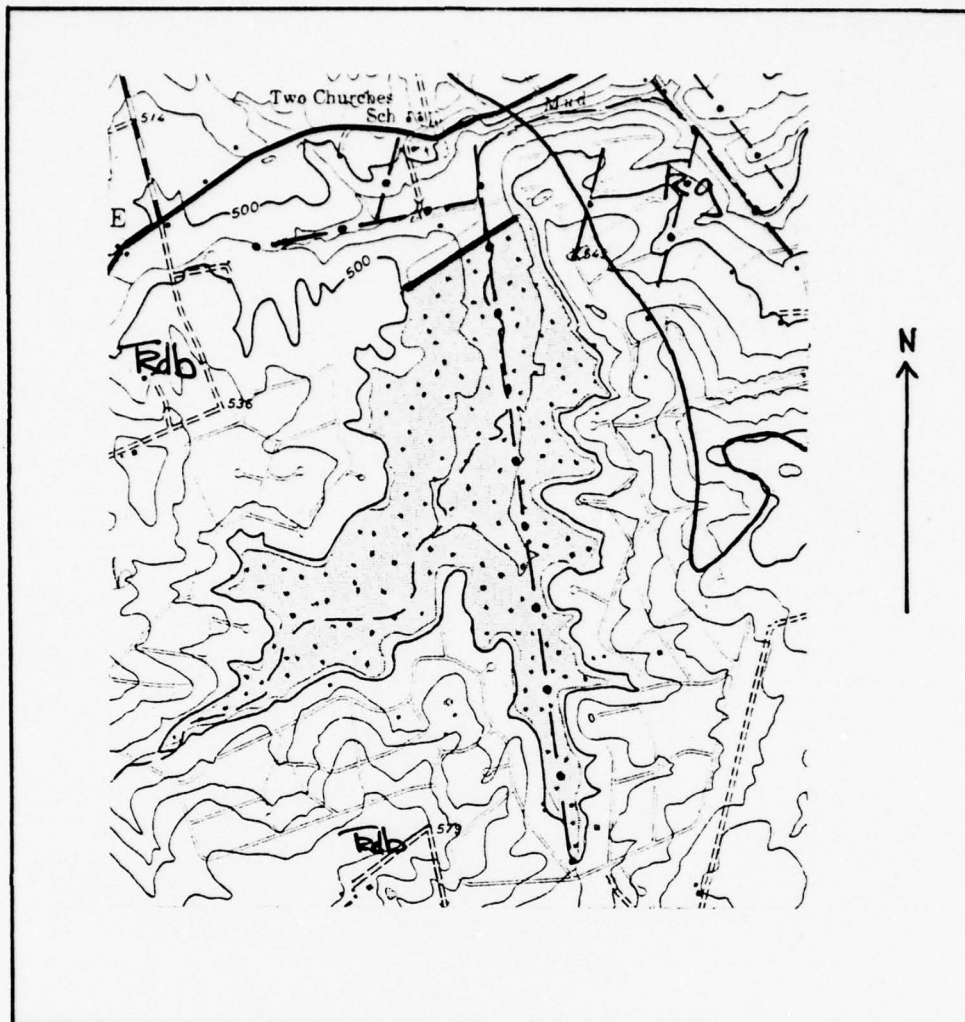
The valley of Mud Creek at the dam site is apparently controlled by a N10°W fracture. N13°E fractures are also present in the area.

The construction drawings specify a three feet deep cutoff trench into rock, but no pressure grouting. There is a distinct possibility of some leakage through the bedrock below the cutoff trench. There is, however, little possibility that continued leakage would cause any disintegration of the bedrock.

Sources of Information

1. Stose, G. W. and Bascom, F. (1929) "Description of the Fairfield and Gettysburg Quadrangles". U.S. Geological Survey Geologic Folio 225.
2. Core boring logs in file.
3. Air photographs 1:24,000, dated 1968.

GEOLOGIC MAP - LAKE MEADE DAM



(geology from U.S.G.S. folio #225)

KEY

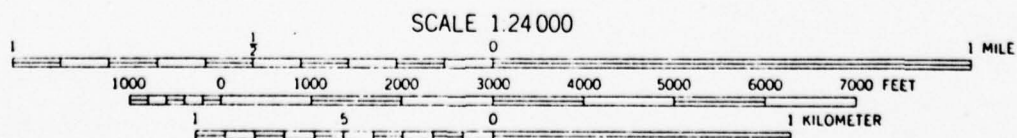
Rdb

triassic diabase

Rg

Gettysburg Shale

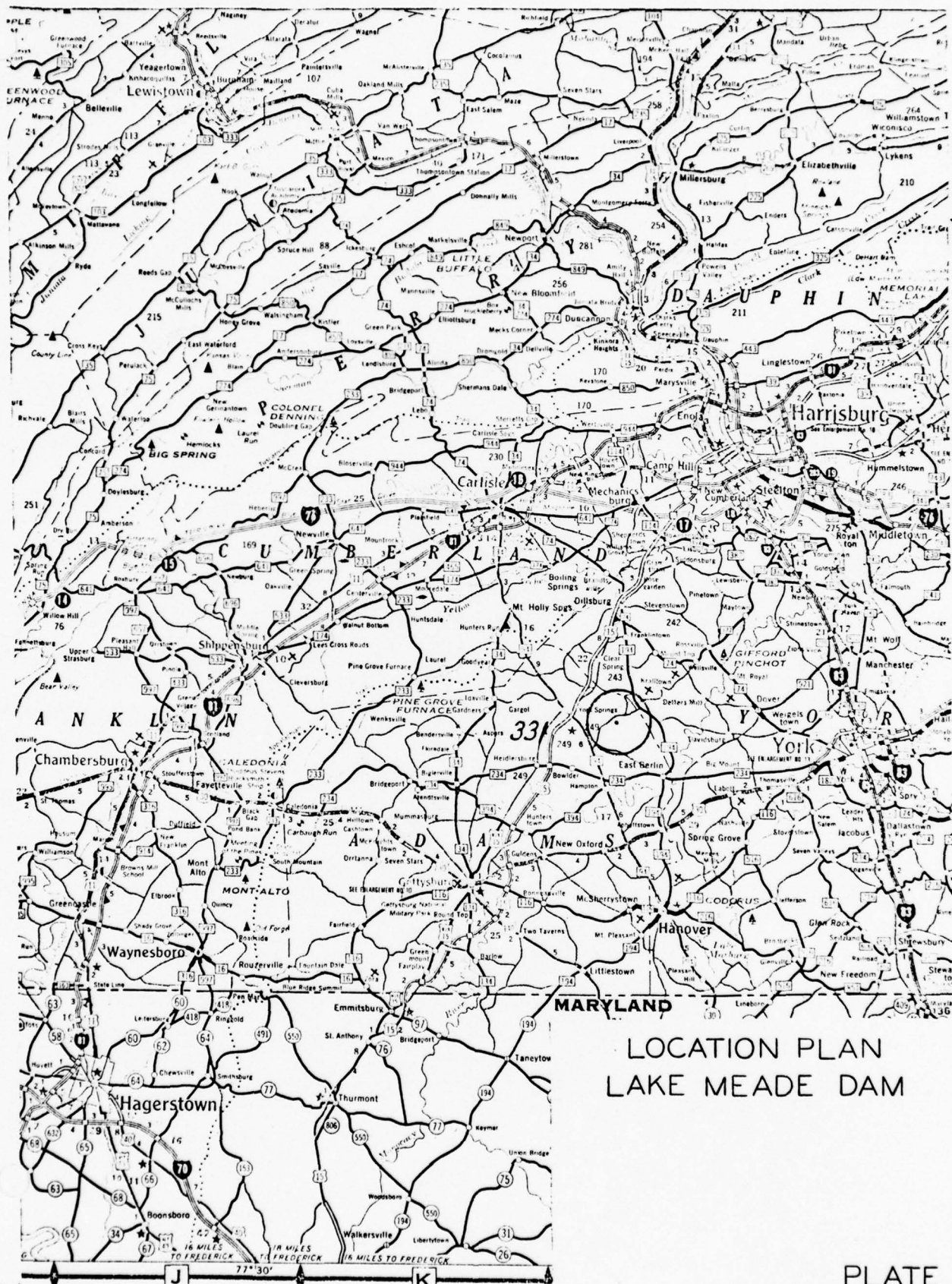
--- air photo fracture trace

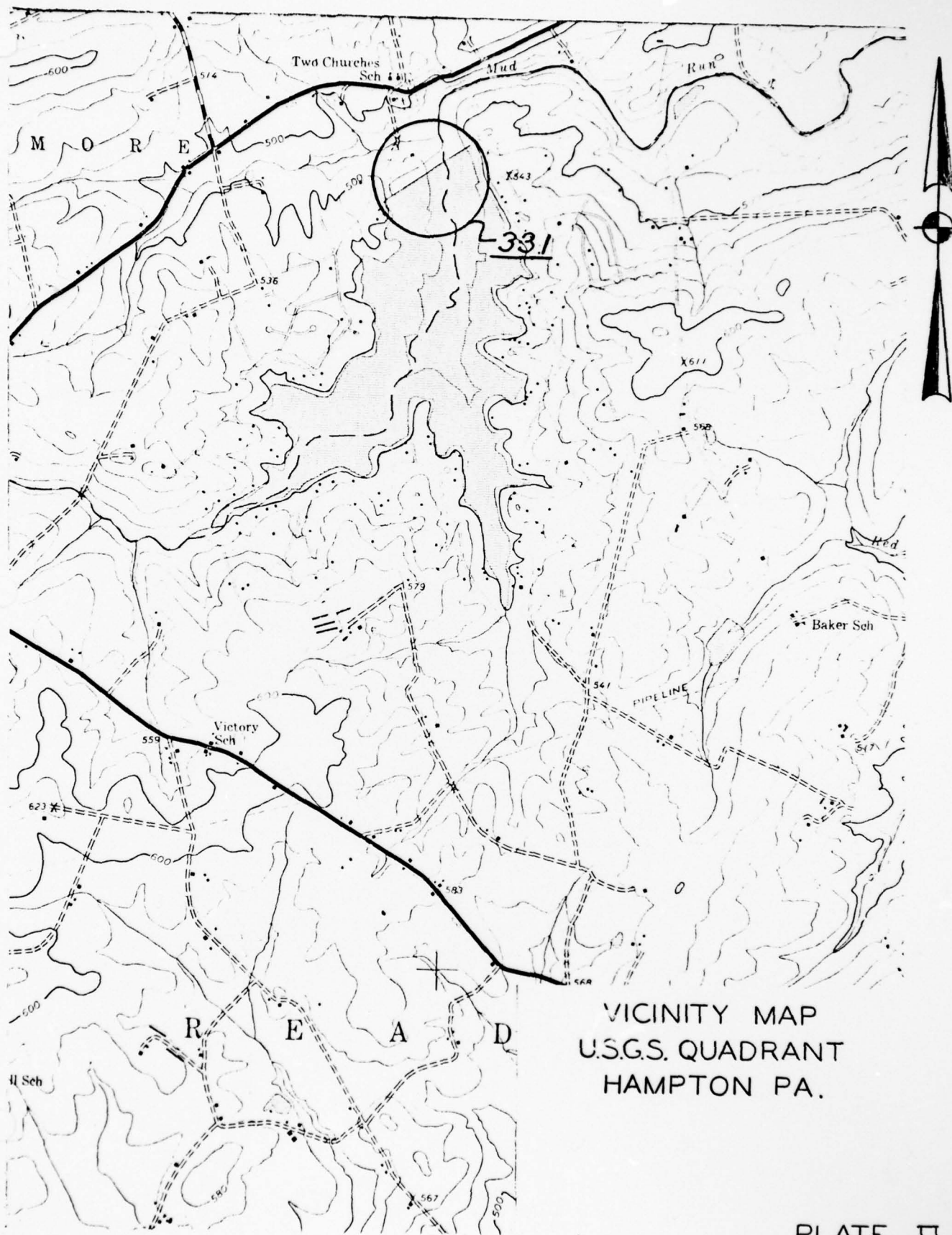


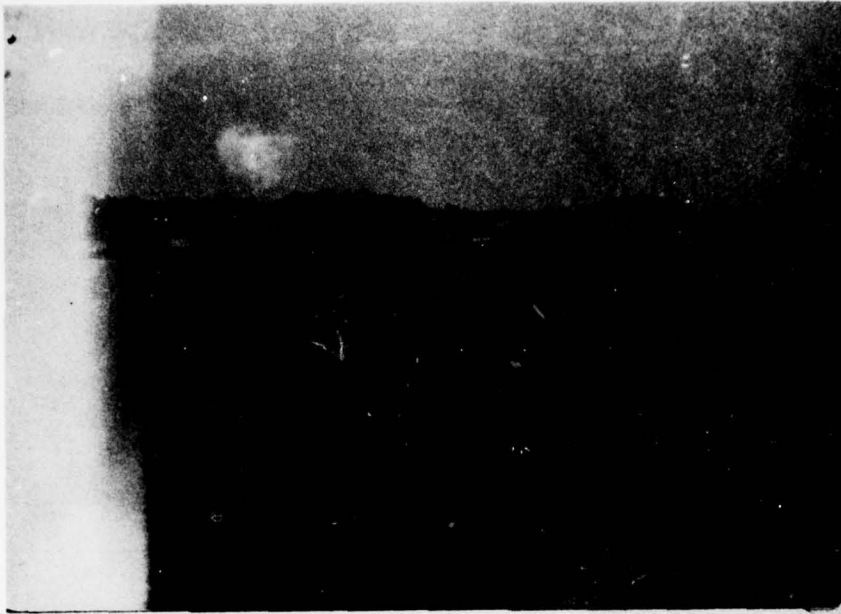
CONTOUR INTERVAL 20 FEET
 DOTTED LINES REPRESENT 10 FOOT CONTOURS

APPENDIX D

LOCATION, PHOTOGRAPHS & DESIGN DRAWINGS







Upstream Slope



Downstream Slope



Fill At Right
Abutment



Downstream Slope



Spillway Channel



Spillway Weir

PLATE IV



Spillway Weir



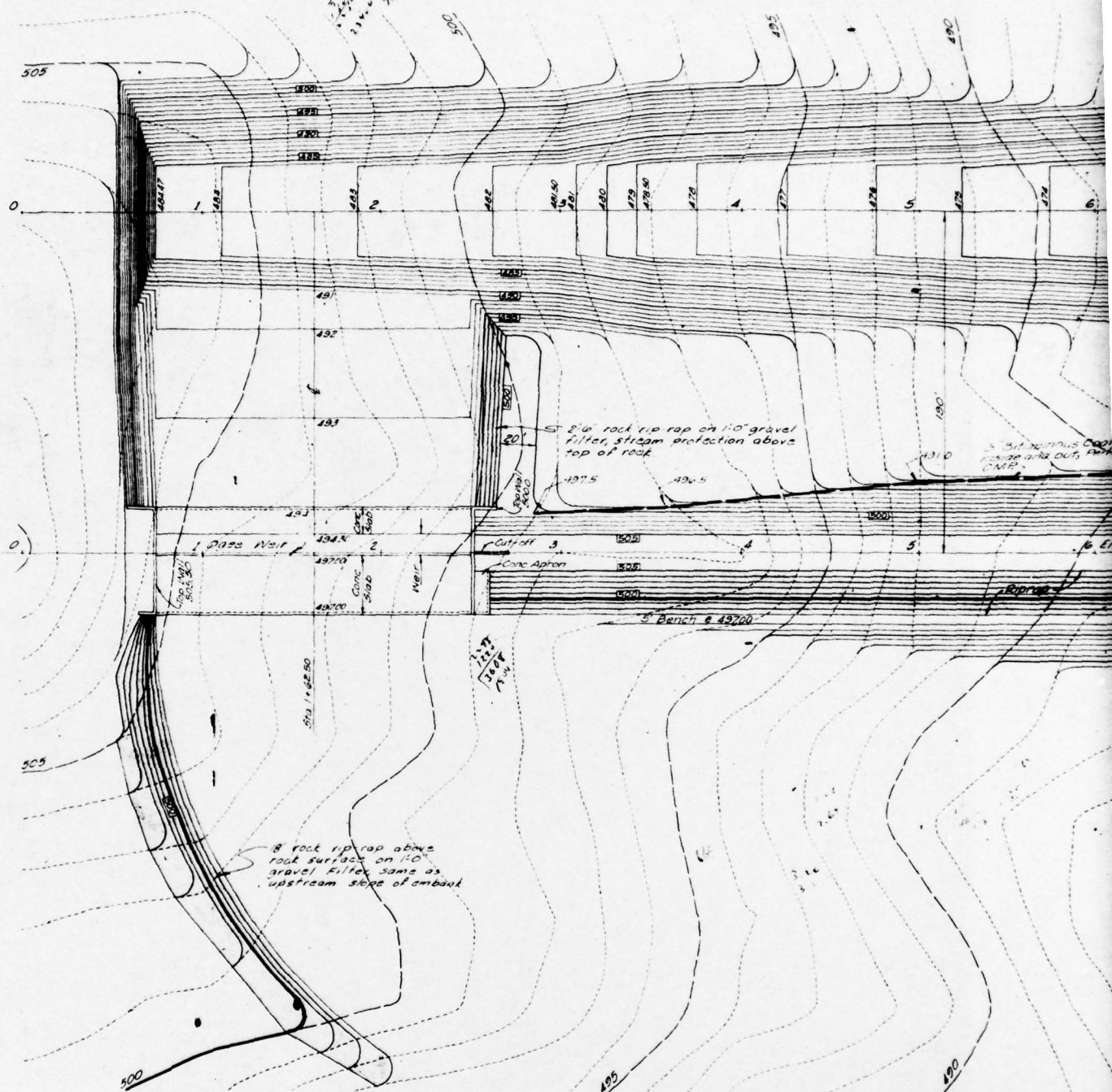
Downstream
Apron Spillway

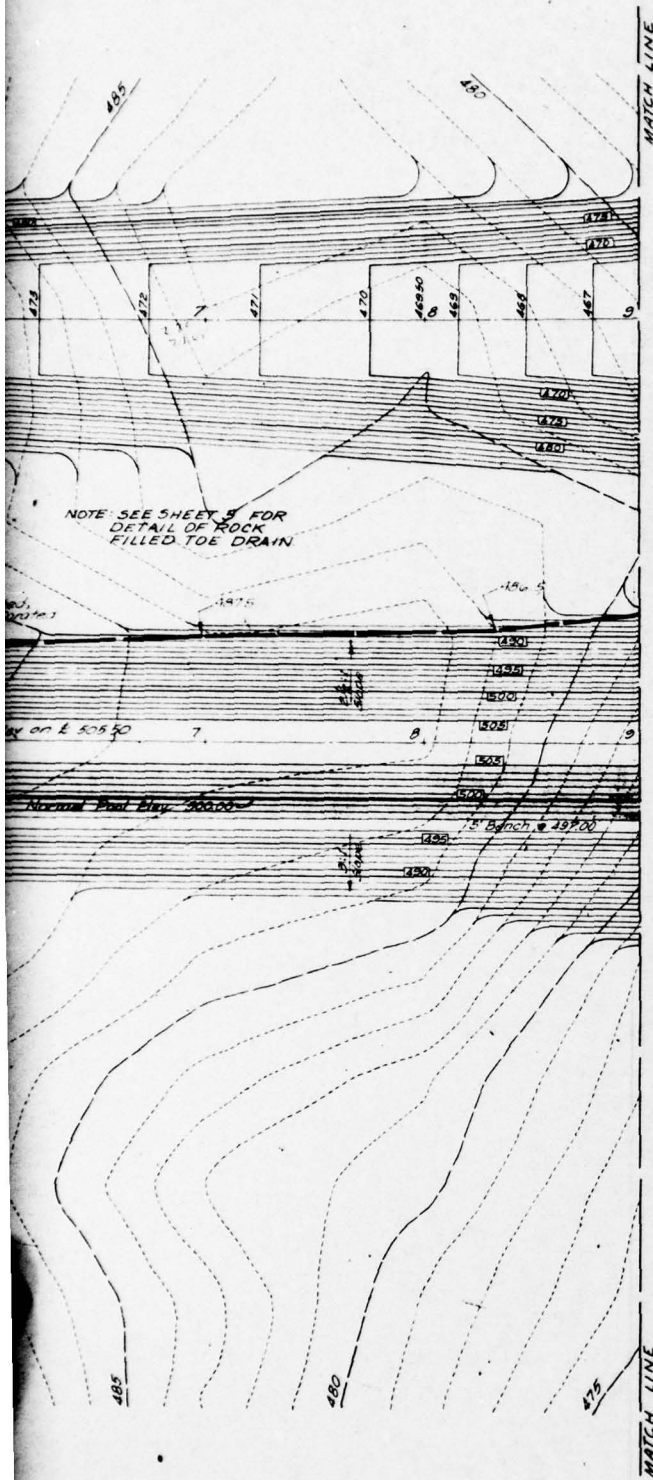


Downstream
Bridge

PLATE V

1-2-28





REC'D _____ FOR _____
 SEE REPORT NO. _____
 Div. Date _____

1-81-3
 FILE NUMBER
 RECEIVED IN THE OFFICE OF THE WATER & POWER
 RESOURCES BOARD, DEPARTMENT OF FORESTS &
 WATERS ON THE 13 DAY OF *Sept* A.D. 19*50*
Arthur H. [Signature]
 File Clerk

331

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FEB 14 1950
e. [Signature]
 G. H. McCumall
 Chief Engineer

Note: All topography furnished
 by American Realty Service
 Corp.

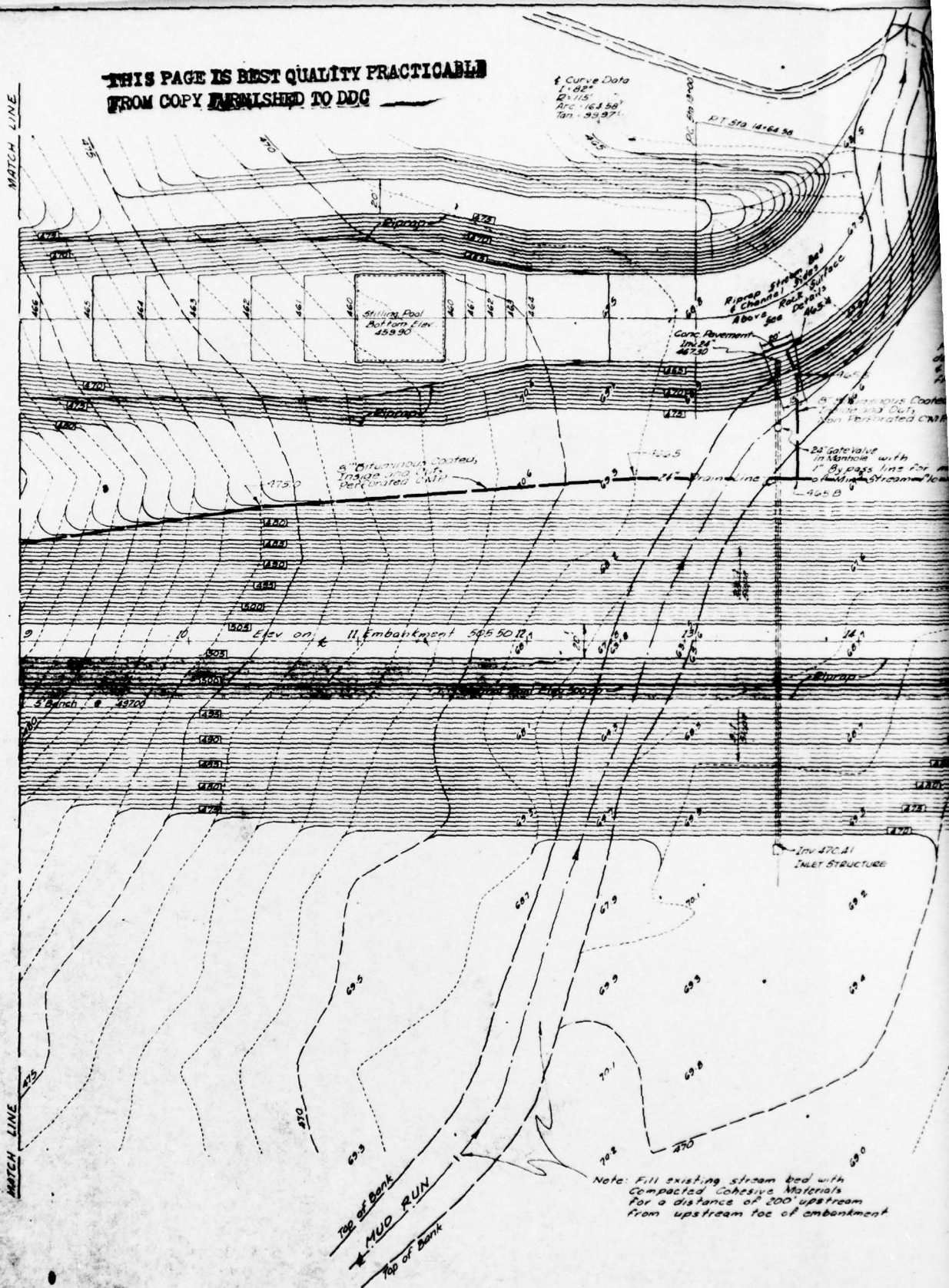
PLATE VI

No.	Date	Revision	LAKE MEADE, INC. LATIMORE AND READING TOWNSHIPS ADAMS COUNTY, PENNSYLVANIA LAKE MEADE PLAN-EMBANKMENT & SPILLWAY
ISSUED DEC 9 1949 RALPH L. WOOLFEY CO.			Scale: 1" = 40' Date: May, 1949 Des: <i>P.N.S.</i> Dr: <i>CHL</i> Cld: <i>P.N.S.</i> Approved: <i>[Signature]</i>
			RALPH L. WOOLFEY CO. CONSULTING ENGINEERS 340 West First St., Englewood, Colo.

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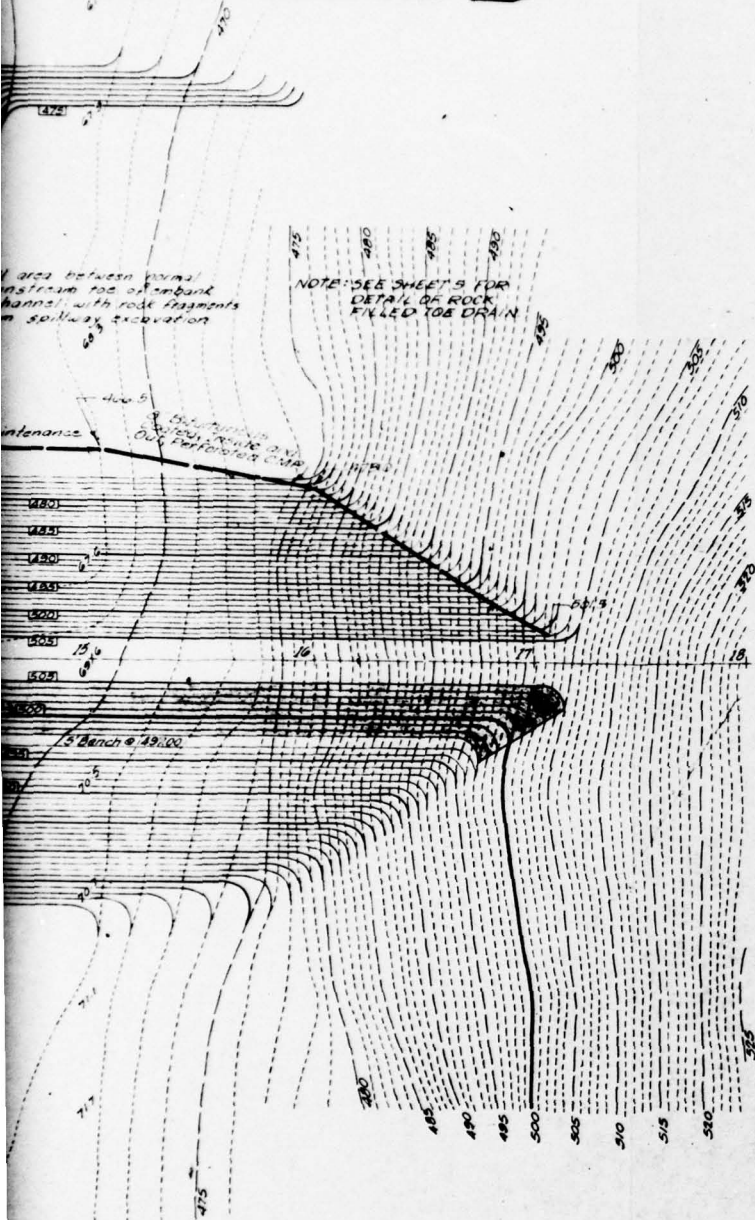
Curve Data
1-82°
2-115°
Arc 163.58'
Tan 33.97'

MATCH LINE



Note: Fill existing stream bed with
Compacted Cohesive Materials
for a distance of 200' upstream
from upstream toe of embankment

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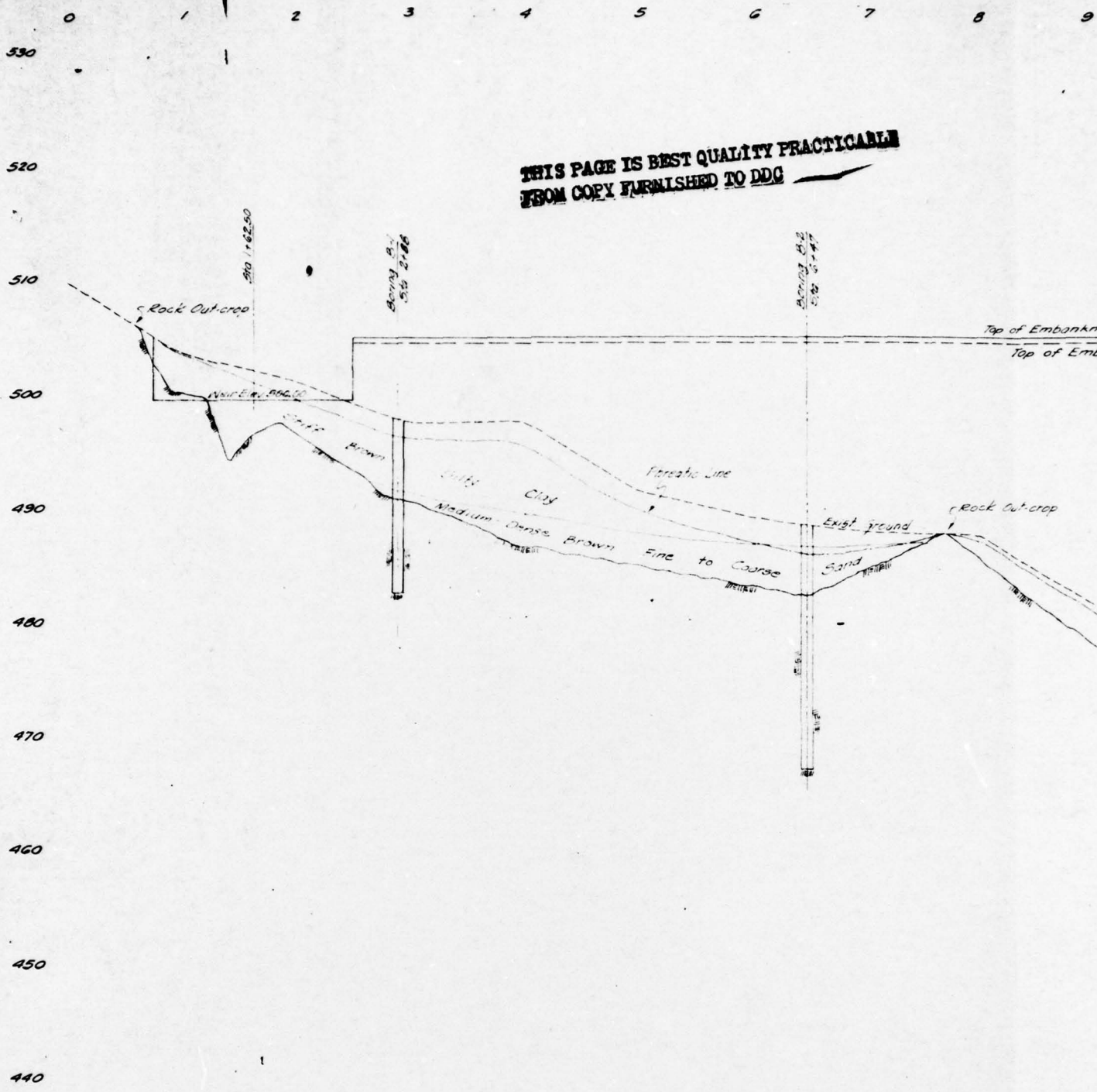
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830
620
1450



No.	Date	Revision

LAKE
EATING
AREA
LAKE
AREA



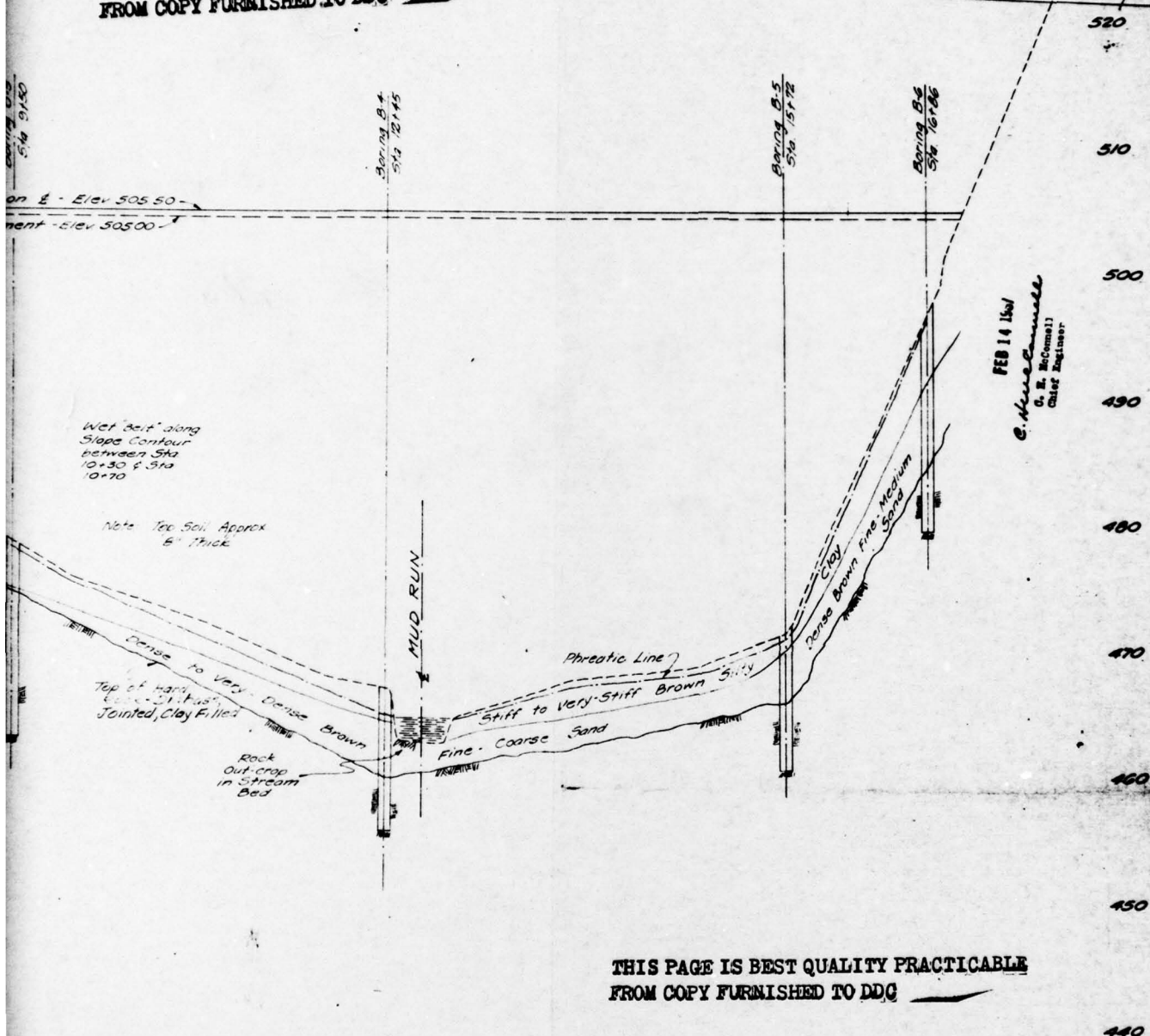
SECTION ALONG CENTERLINE OF

Scale: Horiz. 1" = 60'
Vert. 1" = 6'

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SEE REPORT NO. _____
Div. Date _____

FILE NUMBER 1-81-2
RECEIVED IN THE OFFICE OF THE WATER & POWER
RESOURCES BOARD, DEPARTMENT OF FORESTS &
WATERS ON THE 13 DAY OF Feb. A.D. 1966
Walter H. Greenfield
File Clerk



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PLATE VIII

Note: All Field Work for Profile by
American Realty Service Corporation.
All Soil Test Holes by G.K. Jewell
and Associates. Soil Profile by
G.K. Jewell & Assoc., Soils Engr.
Consultants, Columbus, Ohio.

No.	Date	Revision
1	5/19/66	Soil Profile Information Incomplete
2	6/1/66	Added Soil Profile Data



LAKE MEADE, INC.
LATIMORE AND READING TOWNSHIPS
ADAMS COUNTY, PENNSYLVANIA

LAKE MEADE
LONGITUDINAL SECTION
EMBANKMENT

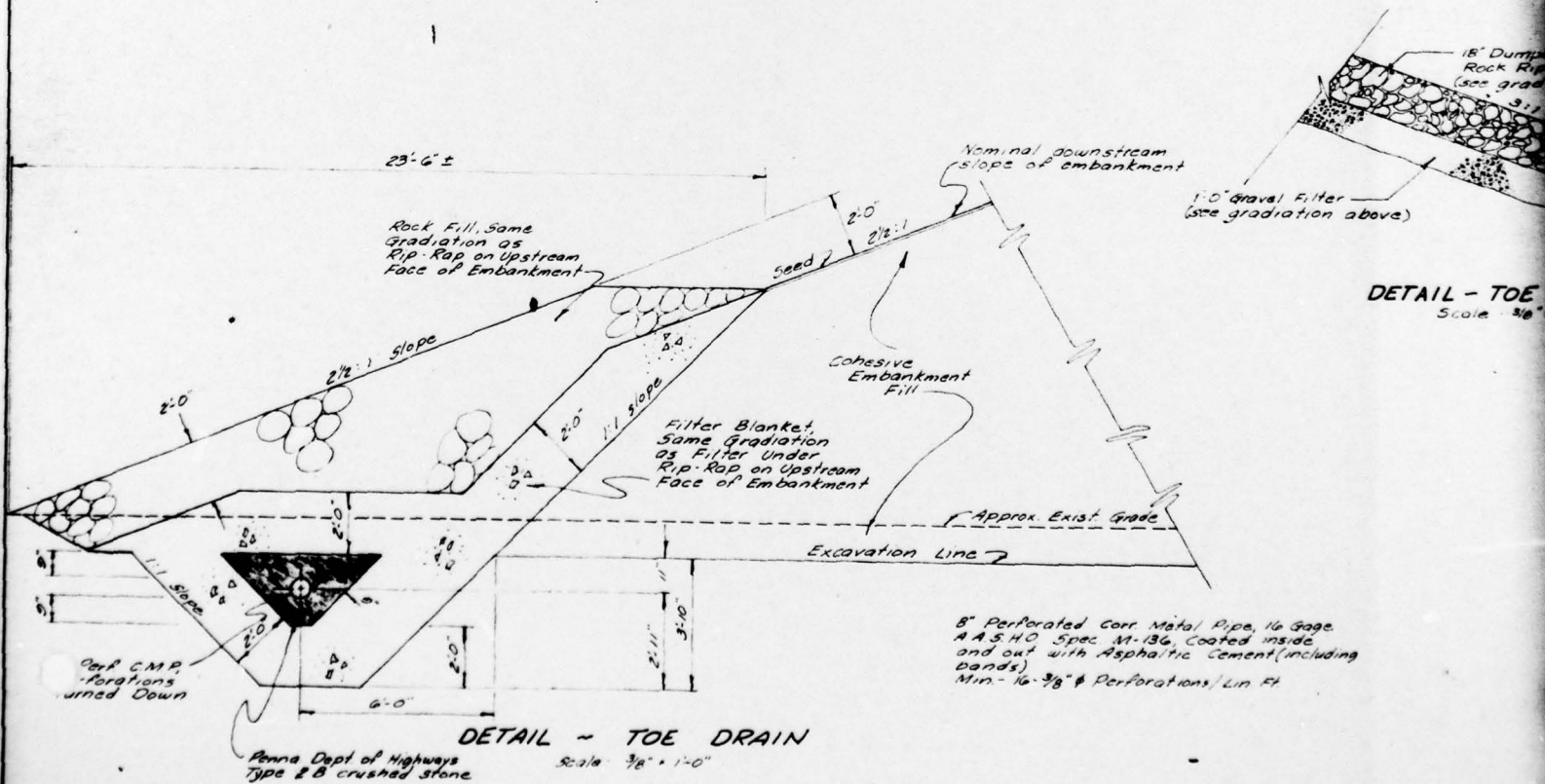
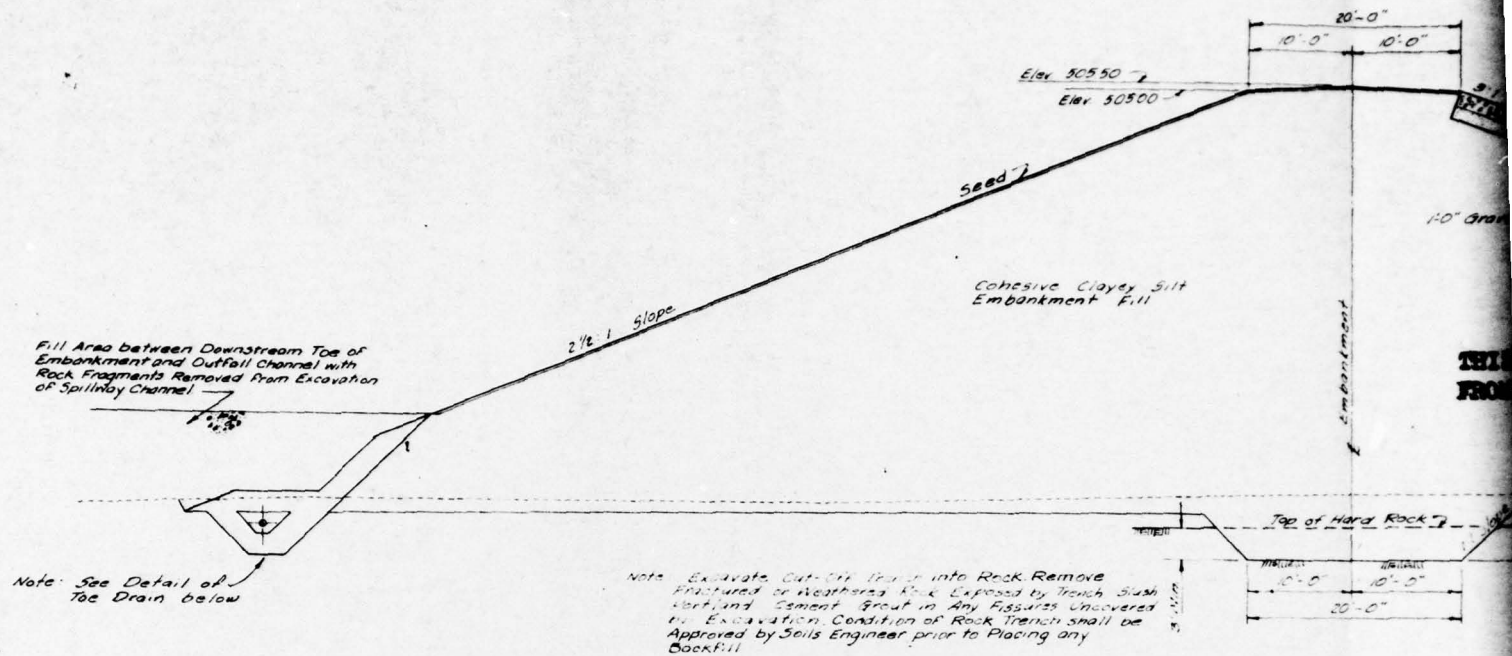
Scale: Horz. 1" = 60', Vert. 1" = 6' Date: May, 1966

Des: T.W. Evans
Dr.: D.R.H.
Ckd: P.N.S.
Ralph L. Woolpert Co.
Consulting Engineers
360 West First St., Dayton 2, Ohio

Approved: A.M. Brown

Contract No. 62-48
Sheet No. 2 of 4
Endsheet

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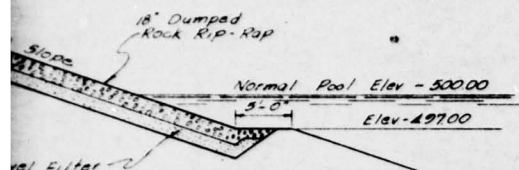


GRADIATION OF RIP-RAP

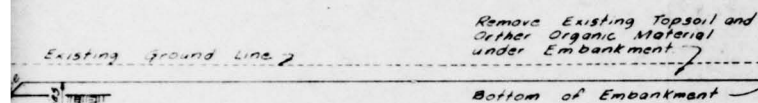
80 % by Weight - 0-32 Lbs
Average Weight - 120-200 Lbs
25 % by Weight - 350-600 Lbs
Maximum Weight - 1000 Lbs

GRADIATION OF GRAVEL FILTER

Std Sieve Size	% of Dry Wgt. Passing
No. 4	100
No. 10	80-95
No. 20	60-85
No. 40	40-50
No. 60	5-30
No. 100	0-10

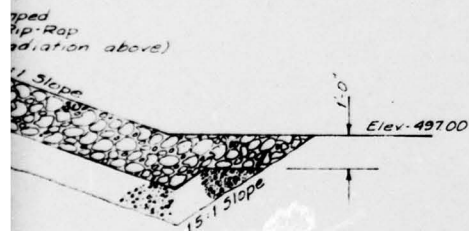


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NOTE: DESIGN OF EMBANKMENT SECTION BY:
G. K. JEWELL AND ASSOCIATES
SOILS AND FOUNDATION ENGINEERS
COLUMBUS, OHIO

TION



E OF RIP-RAP
1:1

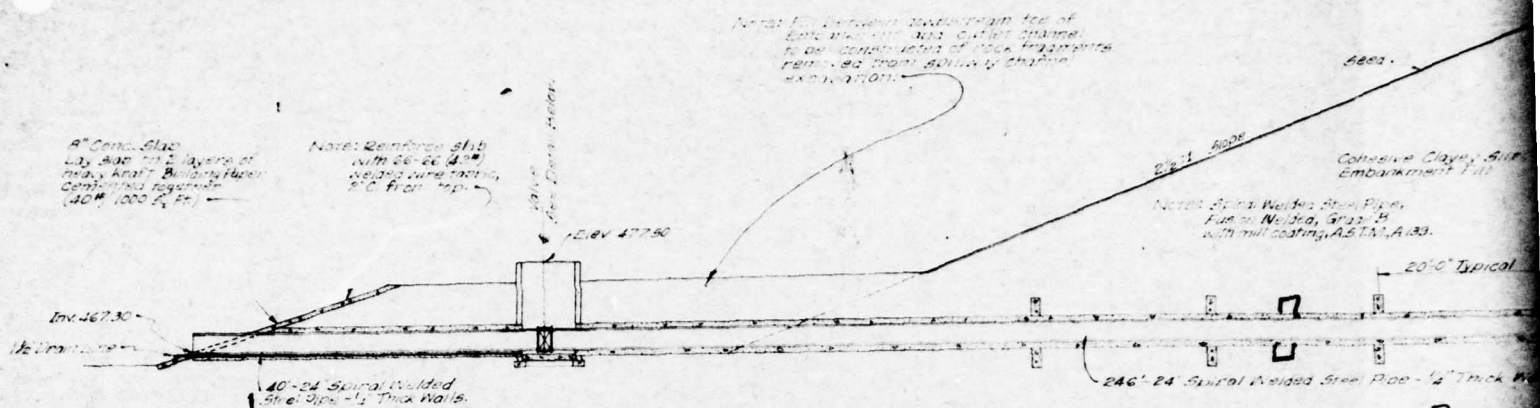
Gradation
Penn. Dept. of Highways
Type 2B Crushed Stone

Std Sieve Size	% by Wgt. Passing
1 1/2"	100
1"	90-100
3/4"	75-90
3/8"	40-60
No. 20	0-10
No. 40	0-5

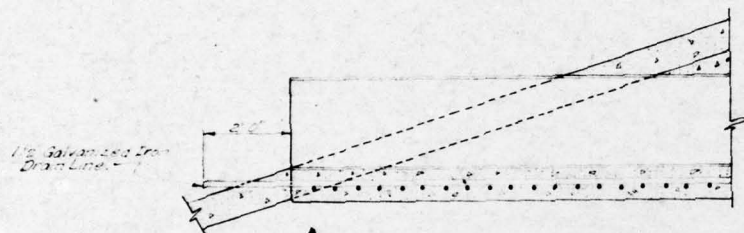
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PLATE IX

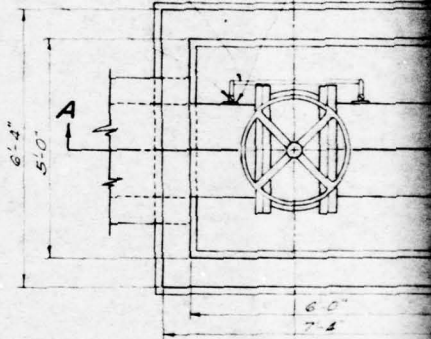
No. Date		Revision		LAKE MEADE, INC. LATIMORE AND READING TOWNSHIPS ADAMS COUNTY, PENNSYLVANIA	
1	3/19/66	Cut-off Trench Extended 3' into Hard Rock		LAKE MEADE DETAILS EMBANKMENT	
<div style="border: 2px solid black; border-radius: 50%; padding: 10px; text-align: center;"> ISSUED DEC 8 1966 RALPH L. WOOLFERT CO. </div>				Scale: As Noted	Date: May, 1966
				Des: G.K.J. Am. Dr.: G.K.J. Cld: P.H.S.	RALPH L. WOOLFERT CO. CONSULTING ENGINEERS 360 West First St., Dayton 2, Ohio Approved: <i>(Signature)</i>



PROFI

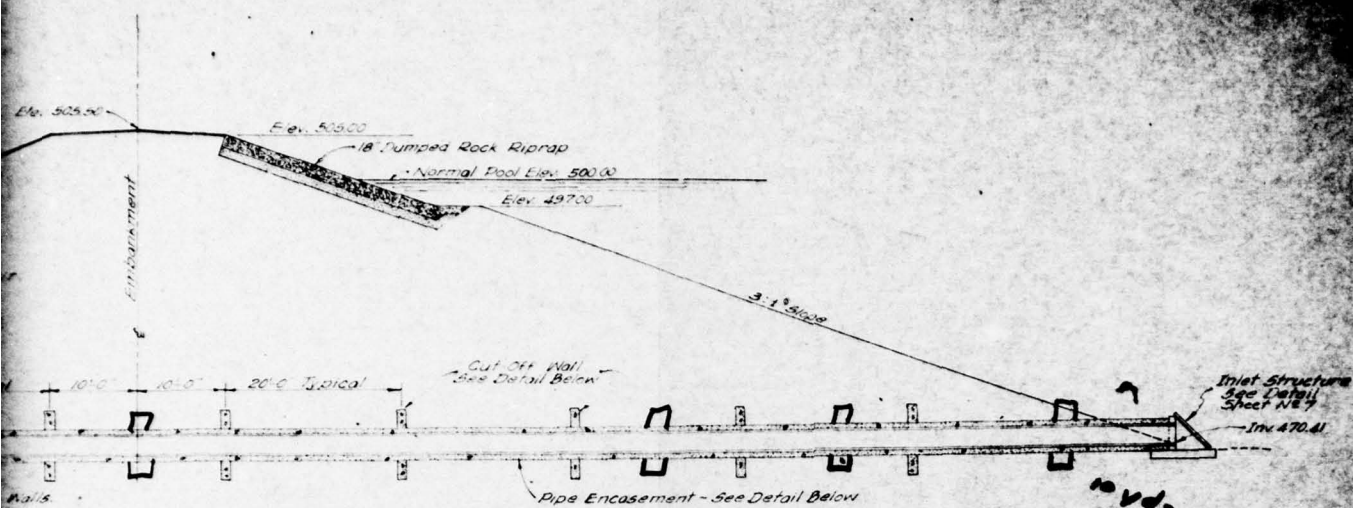


DETAIL - DRAIN LINE OUTLET
Scale 1/2" = 1'-0"



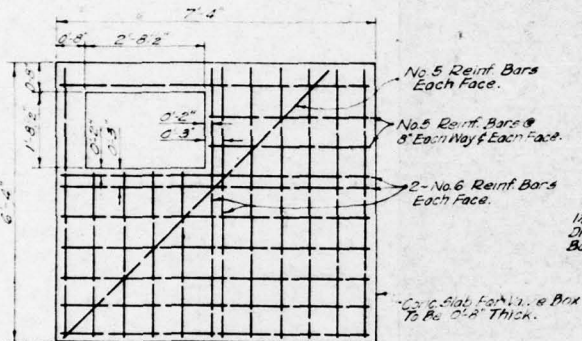
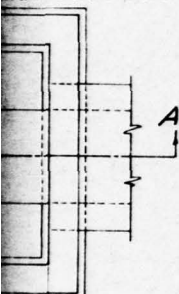
SECTION A-A
DETAIL OF VALVE
Scale 1/2" = 1'-0"

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PROFILE OF DRAIN LINE
Scale: 1"=10'

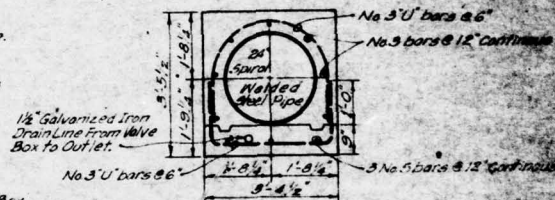
24" Gate Valve to 24" Steel Pipe, 1" Corporation Flange (See Detail Below). Flange to be a minimum 4" thick.



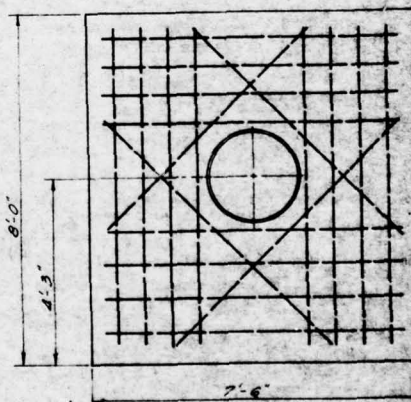
DETAIL OF CONG. SLAB FOR TOP OF VALVE BOX
Scale: 1/2"=1'-0"

24" Gate Valve, 0.5 F.Y., Rising Stem, Rated Pressure - 100 P.S.I., Test Pressure - 200 P.S.I., Class 125 Flanges, Open Right.

\$ 725.00 CONCRETE



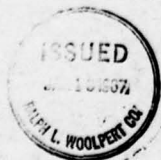
DETAIL OF PIPE ENCASEMENT
No Scale



DETAIL OF CUT-OFF WALL
Scale 1/2"=1'-0"

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PLATE



No.	Date	Revision

LAKE MEADE, INC.
LATIMORE AND READING TOWNSHIP
ADAMS COUNTY, PENNSYLVANIA
LAKE MEADE
DETAILS - DRAIN LINE

Scale: As Noted

Des: R.N.S.

Dr: R.N.S.

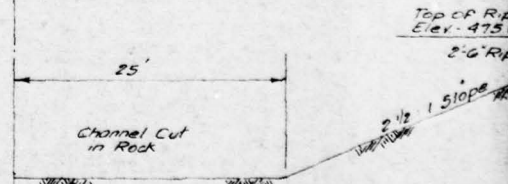
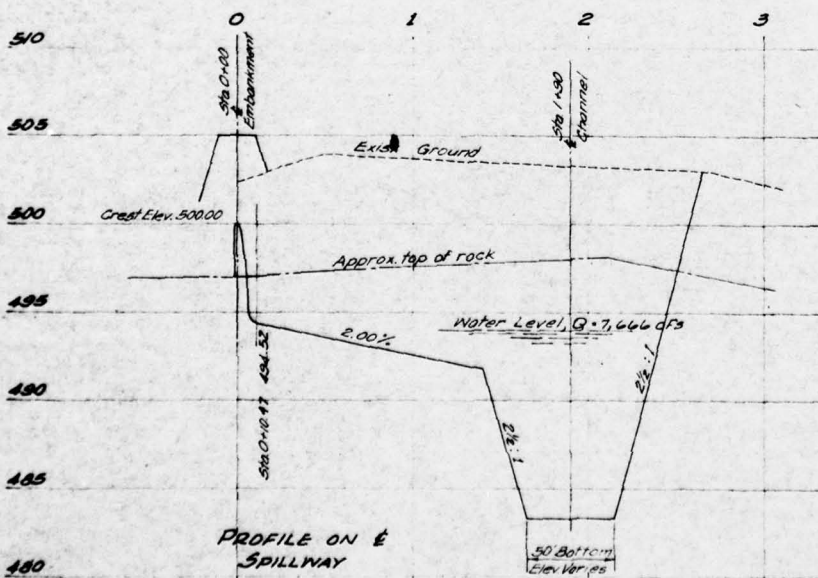
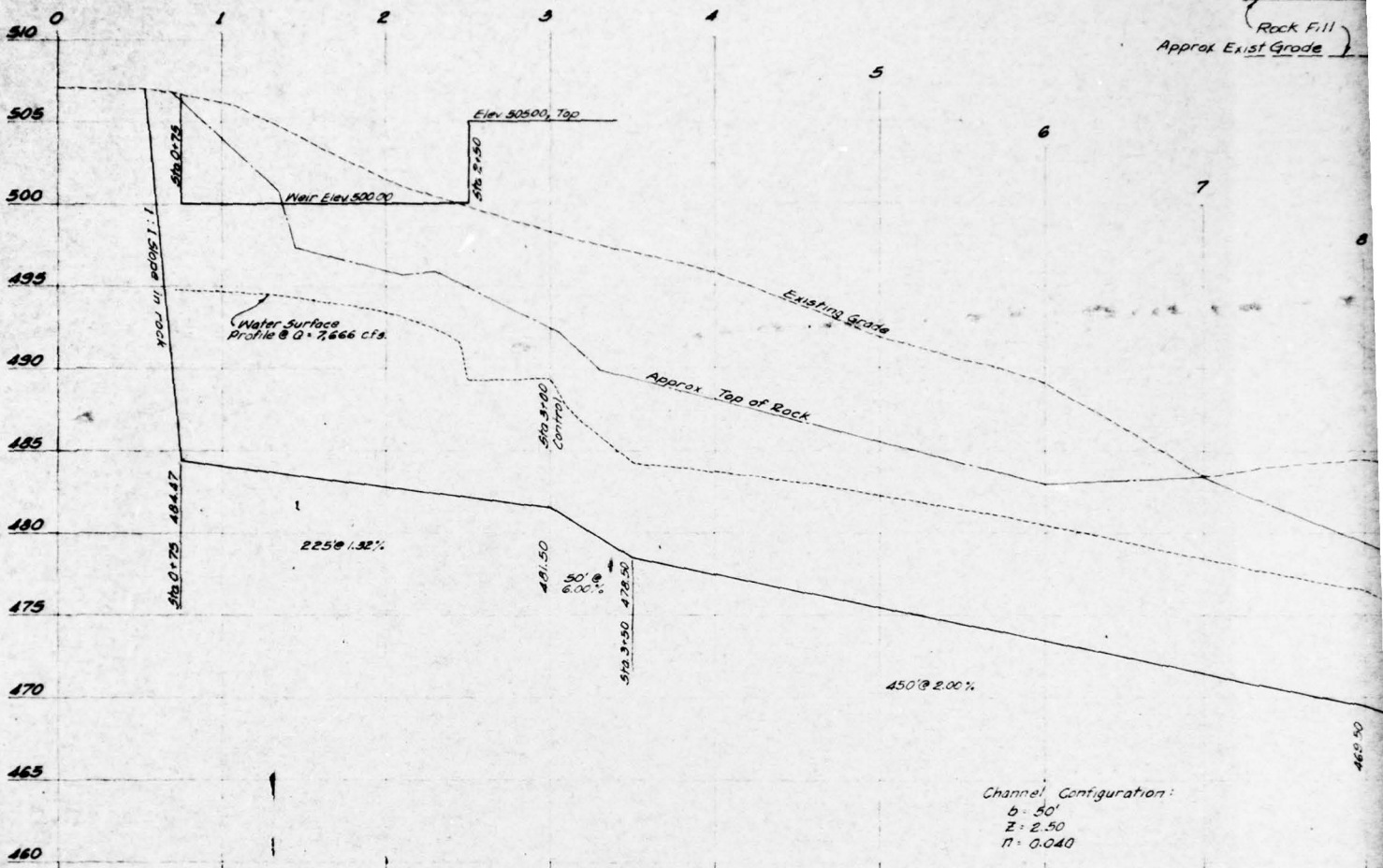
Chd: R.N.S.

Approved:

RALPH L. WOOLPERT
CONSULTING ENGINEER

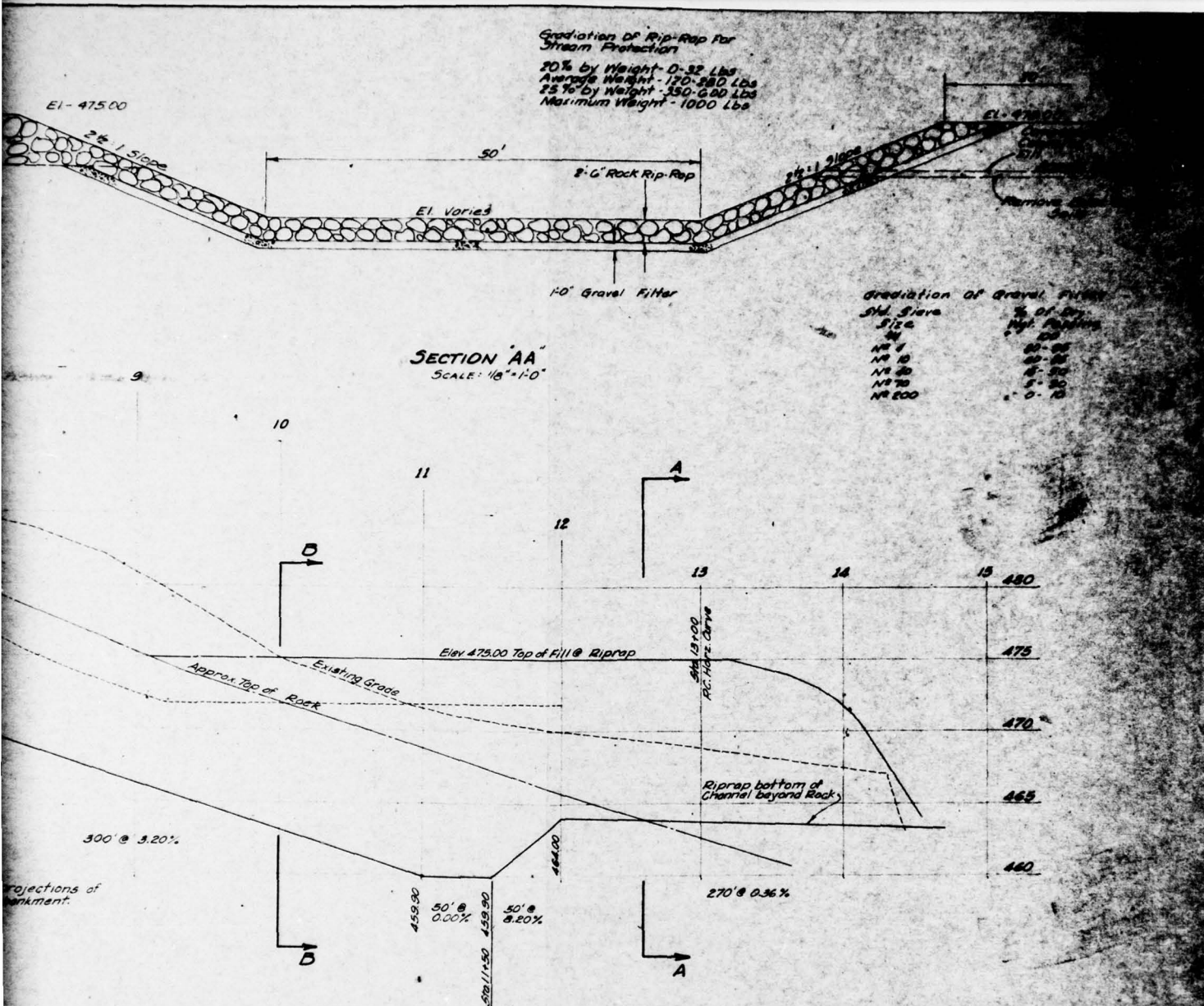
100 West 10th St., Erie, Pa.

100 West 10th St., Erie, Pa.



SECTION BB
 SCALE: 1/4" = 1'-0"

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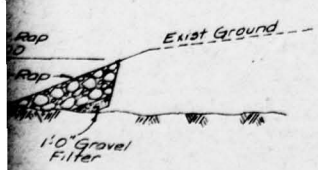
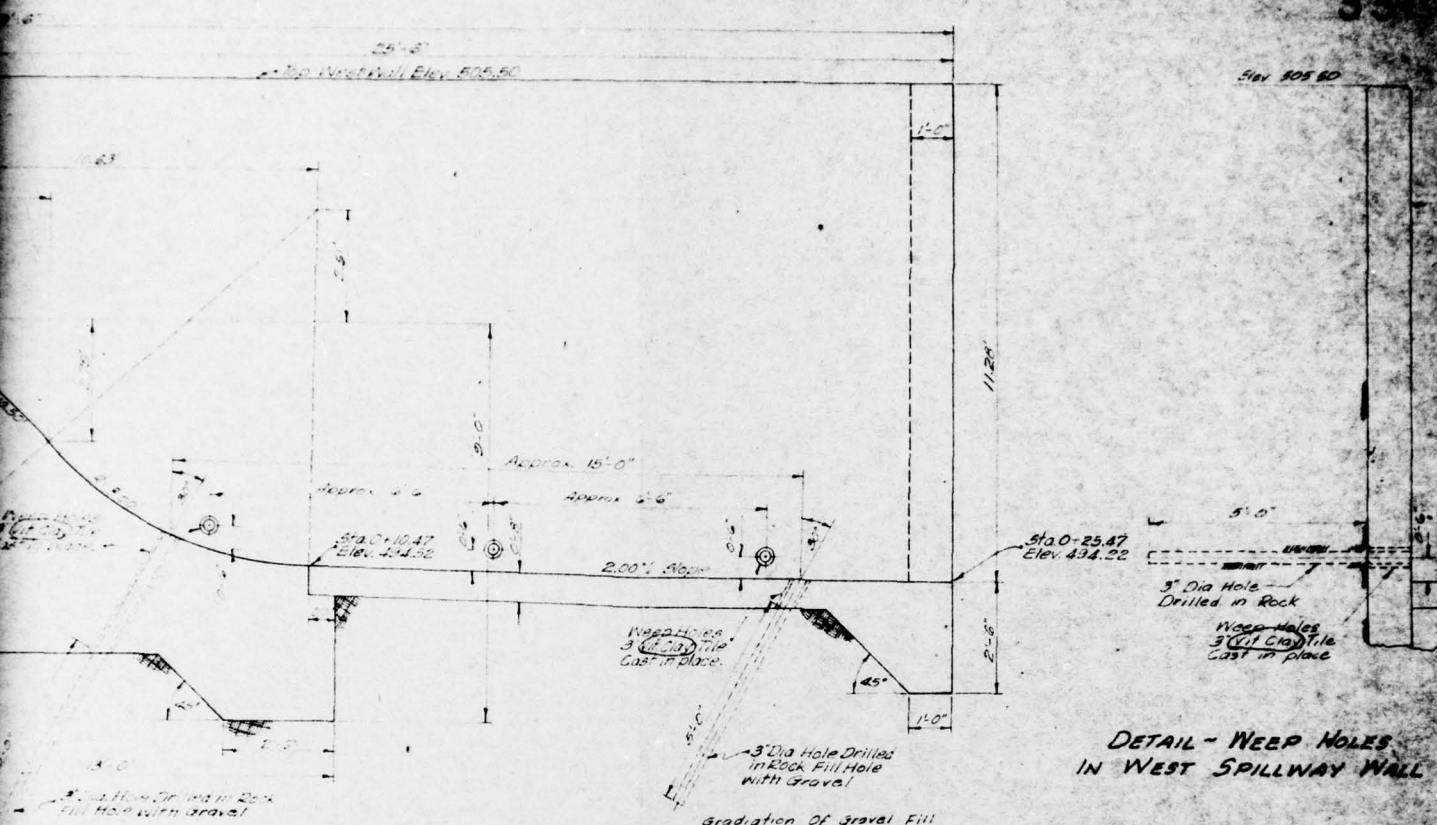


PLATE XI



No.	Date	Revision	LAKE MEADE, INC. LATIMORE AND READING TOWNSHIP ADAMS COUNTY, PENNSYLVANIA	
			LAKE MEADE SECTIONS- SPILLWAY & OUTLET CHANNELS	
			Scale: 1" = 50'	
			Des: R.L.W.	RALPH L. WOOLPERT
			Dr: E.E.T.	Engineer
			Chd: R.L.W.	200 West 10th St., Pittsburgh, Pa.

Sta 1+20.50 on



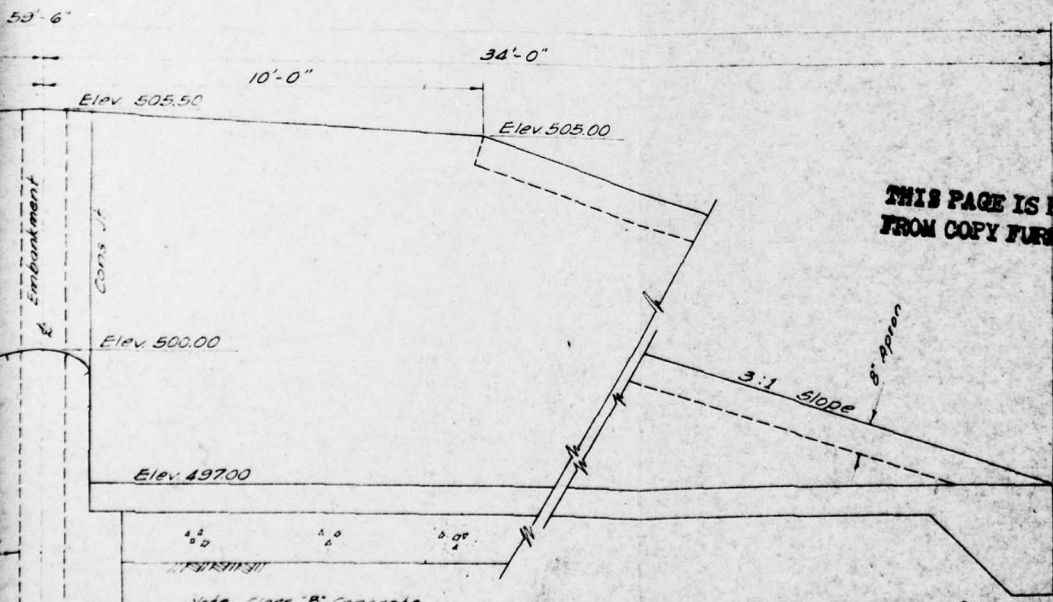
SPILLWAY LOOKING WEST
1/2" = 1'-0"

Gradation of Gravel Fill

Std. Sieve Size	% of Dry Wgt. Passing
No. 4	100
No. 10	80-85
No. 20	60-65
No. 40	45-50
No. 60	35-40
No. 100	25-30
No. 200	10-15

DETAIL - WEEP HOLES
IN WEST SPILLWAY WALL

Use Asbestos Cement Pipe
instead of Vitr. Clay Pipe



SPILLWAY LOOKING EAST
1/2" = 1'-0"

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PLATE XX



No.	Date	Revision

LAKE MEADE, INC.
LATIMORE AND READING TOWNSHIP
ADAMS COUNTY, PENNSYLVANIA
LAKE MEADE
DETAILS - SPILLWAY

Scale: As Noted
Des: P.W.B.
Dr: P.E.T.
Ckd: P.W.B.

RALPH L. WOOLPERT CO.
CONSTRUCTIVE ENGINEERS
240 BROADWAY
NEW YORK 1, N.Y.